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Vol. II

Draft Environmental Impact Statement
for the
Proposed Expansion of Western Energy Company's
Rosebud Mine
into
Areas A and E

JUL 19 '77
STATE DOCUMENTS

VOLUME II

APPENDIXES

Montana Department of State Lands
Helena, Montana
June 9, 1977

Submitted pursuant to
Montana Environmental Policy Act
Section 69-6504(6)(3)

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Table 3 Chemical Properties of Horizon Samples Associated with Coal Areas
Western Energy Area B

Sample # 2 Tullock

Lab No.	Horizon	Depth inches	pH Paste	Sat'n. %	Elect. Cond. mmhos/cm	Saturation Extract Cations Ca meq/liter	Mg meq/liter	Na meq/liter	SAR
7798	A1	0-4	7.9	31.8	0.6	1.5	1.46	0.39	0.20
7799	B1	4-9	7.4	27.3	0.4	0.5	1.67	0.48	0.46
7800	C1	9-21	7.5	26.7	0.4	1.0	1.25	0.39	0.37
7801	C2	21-38	8.1	27.1	0.3	0.75	1.88	0.70	0.61

Table 4 Results of Mechanical Analysis (Hydrometer Method) with Micro Nutrients (DTPA Zn, Fe, Cu, Mn) and Boron

Depth inches	Mechanical Analysis Clay %	Silt %	Sand %	Texture	Zn ppm	Fe ppm	Cu ppm	Mn ppm	B ppm
0-4	11.2	6.4	82.4	SL	0.3	7.0	1.2	5.2	0.5
4-9	10.4	7.2	82.4	LS	0.04	5.5	1.0	4.0	0.4
9-21	11.6	10.8	77.6	SL	0.01	3.8	1.0	2.8	0.2
21-38	8.0	8.4	83.6	LS	0.04	2.4	1.4	1.4	0.5

TULLOCK SERIES

The Tullock series consists of moderately deep, well to somewhat excessively drained, sloping to moderately steep soils on sandstone uplands.

In a typical profile the surface layer is grayish brown fine sandy loam, about four inches thick. The substratum is fine sandy loam to about 38 inches. The soil rests on sandstone at depths between 20 and 40 inches.

The permeability is moderately rapid and the runoff is low.

Typifying Pedon

Tullock Fine Sandy Loam, eight percent slope:

A_1 0-4 inches, grayish brown (10YR 5/2) fine sandy loam; very dark grayish brown (10YR 3/2) moist; weak, coarse crumb structure; slightly hard, very friable, nonsticky and slightly plastic; common fine and very fine roots; clear, smooth boundary.

B_1 4-9 inches, grayish brown (10YR 5/2) heavy sandy loam, very dark grayish brown (10YR 3/2) moist; moderate, coarse prismatic structure; hard, friable, slightly sticky and slightly plastic; common fine and very fine roots; clear, wavy boundary.

C_1 9-21 inches, brown (10YR 5/3) light sandy loam, dark grayish brown (10YR 4/2) moist; weak, coarse prismatic structure, slightly hard, very friable, slightly sticky and slightly plastic; common very fine roots; clear, wavy boundary.

C_2 21-38 inches, light yellowish brown (2.5Y 6/3) light sandy loam, light olive brown (2.5Y 5/4) moist; massive; slightly hard, very friable, nonsticky and slightly plastic; weak effervescence; a few very fine roots; gradual, wavy boundary.

38+ inches, soft sandstone.

Location: 235' W and 25' No of ¼ corner, Sec. 7 & 8; T1N, R41E.

Laboratory Sample #2

Profile texture ranges from sandy loam to loamy fine sand. Content of coarse sandstone fragments ranges from zero to 30 percent.

Table 1 Chemical Properties of Horizon Samples Associated with Coal Areas
Western Energy Area B

Sample # 1 Thurlow Silty Clay Loam

Lab No.	Horizon	Depth inches	pH Paste.	Sat'n. %	Elect. Cond. mmhos/cm	Saturation Extract Cations Ca	Mg	Na	SAR
						------ meq/liter	------	------	
7791	Ap	0-5	7.4	35.8	0.7	0.03	0.31	0.09	0.16
7792	B1	5-8	7.1	36.7	1.4	0.3	12.5	2.83	1.12
7793	B2t	8-12	7.4	40.3	0.8	2.31	4.5	0.91	0.49
7794	B3	12-17	8.1	45.6	1.6	3.75	11.3	3.61	1.32
7795	C1ca	17-24	8.4	51.5	11.4	2.25	165.0	40.4	4.42
7796	C2	24-30	8.5	48.1	12.6	0.45	184.0	45.7	4.76
7797	C3	30-65	8.6	34.8	16.0	0.65	263.0	64.7	5.63

Table 2 Results of Mechanical Analysis (Hydrometer Method) with Micro Nutrients (DTPA Zn, Fe, Cu, Mn) and Boron

Depth inches	Mechanical Analysis % Clay	% Silt	% Sand	Texture	Zn ppm	Fe ppm	Cu ppm	Mn ppm	B ppm
0-5	17.2	18.0	64.8	SL	1.1	9.2	1.4	8.9	1.1
5-8	25.2	8.4	66.4	SL	0.9	9.2	2.6	8.6	0.5
8-12	5.6	9.2	85.2	LS	0.1	8.0	1.8	1.2	0.5
12-17	36.8	20.8	42.4	L	0.03	4.4	1.6	1.2	0.7
17-24	2.0	64.8	33.2	SiL	0.2	6.0	2.0	1.0	1.0
24-30	1.2	68.8	30.0	SiL	0.2	5.8	1.4	1.2	1.4
30-65	2.8	33.6	63.6	SL	0.03	3.9	1.4	1.0	1.5

THURLOW SERIES

The Thurlow series consists of deep, well drained, gently sloping to nearly level soils on terraces, fans, and footslopes. They formed in clayey alluvium washed from mixed shale and silt stone uplands.

In a typical profile the plowed layer is grayish brown heavy silt loam about five inches thick. The subsoil is grayish brown to light yellowish brown heavy silty clay loam, about 12 inches thick. The calcareous substratum is light yellowish brown to light gray silty clay loam to 60 or more inches.

Permeability is moderately slow, and runoff is medium to low.

Typifying Pedon

Thurlow Silty Clay Loam, one percent slope:

A_p 0-5 inches, grayish brown (2.5Y 5/2) heavy silt loam, very dark grayish brown (2.5Y 3/2) moist; massive; hard, friable, sticky and plastic; many fine and very fine roots; clear, smooth boundary.

B_1 5-8 inches, grayish brown (2.5Y 5/2) silty clay loam, very dark grayish brown (2.5Y 3/2) moist; moderate, medium prismatic structure; hard, firm, sticky and plastic; many fine and very fine roots; clear, smooth boundary.

B2t 8-12 inches, grayish brown (2.5Y 5/3) heavy silty clay loam, dark grayish brown (2.5Y 4.2) moist; moderate, medium prismatic structure parting to moderate, medium and fine blocks; very hard, firm, sticky and plastic; many fine and very fine roots; clear, wavy boundary.

B_3 12-17 inches, light yellowish brown (2.5Y 6/3) heavy silty clay loam, light olive brown (2.5Y 5/4) moist; moderate, medium prismatic structure parting to strong, fine blocks; very hard, firm, very sticky and plastic; common very fine roots; weak effervescence; gradual, wavy boundary.

C_{1ca} 17-24 inches, light yellowish brown (2.5Y 6/3) heavy silty clay loam, light olive brown (2.5Y 5/4) moist; weak, medium prismatic structure parting to weak, medium blocks; very hard, firm, very sticky and very plastic; strong effervescence; common very fine roots; gradual wavy boundary.

C_2 24-30 inches, light gray (2.5Y 7/3) silty clay loam, light yellowish brown (2.5Y 6/4) moist; weak, medium prismatic structure parting to weak, medium blocks; hard, firm, sticky and plastic; strong effervescence; common fine roots; clear wavy boundary.

Red Rock Outcrop Complex Steep (Sb)

This complex comprises red rock outcrops and steep soils on uplands. About 60 percent is red rock outcrop and about 20 percent is Remitt fine sandy loam, red phase.

Included in mapping is about 20 percent soils that are 1- to 20 inches deep from red bedrock. The Remitt soil has a typical profile for the series, except that it is red in color.

Risk of erosion is moderate for water and wind.

None of this very shaley, channery and gravelly loam material is suitable for stockpiling. The isolated pockets of Remitt soils are so small, discontinuous, and of such steep slopes that they are impractical to excavate by conventional methods. Material coarser than three inches makes up to 30 to 75 percent of the volume of the identifiable soils in these areas.

Remitt Fine Sandy Loam, Red Phase, 2 to 8 percent Slopes (Rc). This soil is found on gently and moderately sloping fans in replaced valleys. It differs from the profile described as typical for the series in being red.

Risk of erosion is slight for water and severe for wind.

Recommendations for Stockpiling:

The upper 5 feet of this soil is suitable for stockpiling. Locally, where the fans merge with the soils along major drainageways, the usable depth may reach up to 8 feet. The material below 2 feet, being low in organic matter and clay is easily wind eroded.

Shale Outcrop-Elso Complex, Very Steep (Sa). This complex is found on very steep broken slopes of the uplands. Elso loam is on ridges and knolls and on some of the steep side slopes. Loamy and clayey shale outcrops are mainly present on very steep slopes.

This complex is about 60% shale outcrop and about 30% Elso soil. The Elso soil has a typical profile for the series. About 10% of each mapped area consists of shallow clay and clay loam soils.

Risk of erosion is severe for water and moderate for wind.

Recommendations for Stockpiling:

None of this mixture of shallow soil material and raw shale is suitable for stockpiling. Slopes of more than 25% and the predominance of shale outcrops on the landscape make excavation difficult.

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Date Rec'd

Date Sent

RESULTS OF DEEP SOIL SAMPLE ANALYSIS

From:

Montana Testing Laboratories, Inc
P. O. Box 2318
Great Falls, Montana 59401

FOR: (Grower) Western Energy

CLIENT: (Dealer)

REMITT

Lab No.	Field No.	Depth (Inches)	pH	Organic Matter %	Nitrate Nitrogen ppm	Lbs./Ac. N	Phosphorus P ppm	Potassium K ppm	Calcium Ca meq/100g	Magnesium Mg meq/100g	Sodium Na meq/100g	Salt Hazards mmhos	Soil Texture	Available H2O (Inches)
9010		0-14	7.7	1.0	0.25		14.5	2[illegible]3	[illegible]	5.0	0.1	0.5	FSL+	0
9011		14-2[illegible]	7.9	0.5	0.25		12.5	95	32.4	3.8	0.1	0.3	FSL	[illegible]
9012		[illegible]-50	7.9	0.08	0.25		17.5	63	34.1	7.1	0.1	0.4	FSL+	M
9013		[illegible]-72	8.2	0.08	0.25		7.7	2.5	21.5	7.3	0.1	0.4	FSL+	M+

OTHER TESTS REQUIRED

Sulfur ppm	Zinc ppm	Iron ppm	Copper ppm	Manganese ppm	Boron ppm	0.3 ATM	15 ATM	Lime or Gypsum	Cation Exchange Capacity (CEC)	Mechanical Analysis			Others
										% Clay	% Silt	% Sand	
3.4	0	7.0	2.3	10.0		11.8	5.9			26.8	34.4	38.8	L
0	0	4.9	1.4	5.2		9.06	4.53			14.8	30.4	54.8	SL
0	0	3.8	1.4	3.2		9.59	4.79			15.8	3.4	80.8	SL
0.7	0	3.0	1.1	1.4		9.59	4.79			15.8	2.4	81.8	SL

REMITT SERIES

The Remitt series consists of deep, well drained, moderately sloping and gently rolling soils on fans and footslopes. These soils are formed in sandy alluvium and aeolean sands. Annual precipitation is ten to 14 inches.

In a typical profile the surface layer and subsoil are grayish-brown fine sandy loams about 12 inches thick. The substratum is light yellowish brown, stongly calcareious fine sandy loam.

Permeability is moderately rapid, and runoff is slow.

Typifying Pedon

Remitt fine sandy loam, four to eight percent slopes:

Ap-0-6 inches, grayish-brown (2.5y 5/2) fine sandy loam, dark grayish-brown (2.5y 4.2) moist; weak fine crumb structure; soft when dry, very friable when moist; nonsticky and nonplastic when wet; weak effervescence; abrupt wavy boundary.

B2-6-12 inches, grayish-brown (10yR 5/2) fine sandy loam, dark brown (10yR 4/3) moist; weak coarse prismatic structure; soft when dry, very friable when moist; nonsticky and nonplastic when wet; common fine and very fine and few medium roots, common fine and very fine pores; strong effervescence; clear wavy boundary.

C1ca-12-36 inches, light yellowish-brown (2.5y 6/3) fine sandy loam, light olive brown (2.5y 5/4) moist; massive; soft when dry, very friable when moist, nonsticky and nonplastic wet; common fine and very fine roots; common fine and very fine pores; strong effervescence and few fine, faint threads and masses of line; diffused boundary.

C2-36-60 inches, light yellowish-brown (2.5 6/3) fine sandy loam light olive brown (2.5y 5/4) when moist; massive; soft, very friable, nonsticky and nonplastic; few fine and very fine roots; strong effervescence.

McRae loam, 15 to 35 percent slope (Mt). This mapping unit consists of eroded, disected edges of fans along drainageways, and the narrow floor of the drainageways. The unit follows the course of the drainageways and is seldom more than 200 feet wide. The slopes are short and steep on the sides of the drainageways and leveled on the bottom.
The soil profile differs from the normal McRae in that erosion has removed the upper leyers, and the subsoil below 20 inches is more variably stratified with textures of silt loam and fine sandy loam. Risk of erosion is severe for water and slight for wind.

Recommendations for Stockpiling:

The upper five feet of this soil is suitable for stockpiling. In the widest valleys the depth along the stream channel reaches up to 10 feet. The possibility of a water table below the 5 foot depth exists where sandstone bedrock or coal seams underlie the soil.

McRae loam, 0 to 2 percent slopes (Mc). This soil is found on nearly leveled terraces. The profile is typical for the series.
Risk of erosion is slight for both water and wind.

Recommendations for Stockpiling:

This soil is suitable for stockpiling to a depth of 5 feet. As indicated in maps, there are large areas of usable depths of 6 to 8 feet. Below the 8 foot depth unsuitable textures of clay loam or silty clay loam may be encountered along the main drainageways of the large fans.

McRae-Elso loams, 6 to 15 percent slopes (Mcc). This complex comprises moderately steep soils found on rolling uplands and fans. It is composed of about 60% McRae loam, 25% Elso loam and 15% Cushman soils. The McRae loam occupies the fans and lower footslopes, and the Elso loam occupies the ridges and knolls. The McRae and Elso soils in this complex are similar to the ones described as typical for the serieis, except that in some of the McRae loam the depth to soft shales and sandstones is between 40 and 60 inches.
Risk of erosion is severe for water and moderate for wind.

Recommendations for Stockpiling:

The McRae soil in this complex is suitable for stockpiling to a depth of 5 feet. Below this depth it is suitable only if the texture is not finer than silty clay loam.

The Elso soil is suitable stockpiling but has a depth range of 1 to 2 feet over the underlying soft shale and siltstone.

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RESULTS OF DEEP SOIL SAMPLE ANALYSIS

Montana Testing Laboratories, I
P. O. Box 2013
Great Falls, Montana 59401

Western Energy

McRae

CLIENT:
(Dealer)

No.	Your Field No.	Depth Inches	pH	Organic Matter %	Nitrate Nitrogen ppm	Lbs./Ac. N	Phosphorus P ppm	Potassium K ppm	Calcium Ca meq/100g	Magnesium Mg meq/100g	Sodium Na meq/100g	Salt Hazards mmhos/cm	Soil Texture	Avail. H₂O LIME
135		0-6	7.9	2.9	22.95		17.5	213	20.3	5.3	0.1	0.6	SiCL-	M-
136		6-16	8.2	0.9	7.5		5.0	88	+35	8.0	0.1	0.5	L	M+
137		16-24	8.3	0.1	1.85		5.0	63	+35	11.9	0.1	0.5	L+	M+
138		24-36												
139		36-66	9.0	0.1	0.25		21.0	2.5	34.1	8.0	1.0	0.6	L	M

OTHER TESTS REQUIRED

Sulfur ppm	Zinc ppm	Iron ppm	Copper ppm	Manganese ppm	Boron ppm	0.3 ATM	15 ATM	~~Lime or Gypsum~~ SAR	Cation Exchange Capacity (CEC)	Mechanical Analysis % Clay	% Silt	% Sand	Others Texture
33	0.05	5.0	1.6	4.8		10.57	5.29			30.8	50.4	18.8	SiCL
4.1	0	5.5	2.0	5.2		11.78	5.89			26.8	34.4	38.8	L
43.4	0.3	4.6	1.8	2.8		14.92	7.46			24.8	46.4	28.8	L
18.2	0	4.0	1.2	3.4		7.96	3.98			12.8	48.4	38.8	L

MCRAE SERIES

The McRae series consists of deep, well drained nearly level to moderately sloping, calcareous soils on fans and terraces. These soils are formed in loamy alluvium. Annual precipitation is ten to 14 inches.

In a typical profile the surface layer and subsoil are light brownish-gray loam about 12 inches thick. The substratum is light gray loam and fine sandy loam. It is strongly calcareous and contains light gray masses of lime.

Permeability is moderate, and runoff is medium.

Typifying Pedon

McRae loam, 4 to 8 percent slopes:

Ap-0-6 inches, light brownish-gray (2.5y 6/2) loam, dark grayish-brown (2.5y 4.2) moist; moderate fine crumb structure; slightly hard when dry, friable when moist, slightly sticky and plastic when wet; strong effervescence; abrupt wavy boundary.

B2-6-12 inches, light brownish-gray (2.5y 6/2) loam, olive brown (2.5y 4/4) moist; moderate medium prisms that separate to weak medium and fine subangular blocks; slightly hard, friable, slightly sticky and plastic; common fine and very fine and few medium roots; many fine and very fine pores; strong effervescence; clear wavy boundary.

B3ca-12-20 inches, pale-yellow (2.5y 7/3) loam, light olive-brown (2.5y 5/4) moist; weak coarse subangular blocks; hard, friable, slightly sticky and plastic; common fine and very fine roots; common fine and very fine pores; strong effervescence with common faint masses and threads of lime; diffused boundary.

Clca-20-24 inches, pale-yellow (2.5y 7/3) loam, light olive-brown (2.5y 5/4) moist; weak medium subangular blocky structure; hard, friable, sticky and plastic; common fine and very fine roots; many fine and very fine pores; strong effervescence; few faint masses and threads of lime; gradual boundary.

C2-24-60 inches, pale-yellow (2.5y 7/3) fine sandy loam, olive-brown (2.5y 4/4) moist; massive; slightly hard, very friable, slightly sticky and nonplastic; few fine and very fine roots; strong effervescence.

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RESULTS OF
DEEP SOIL SAMPLE ANALYSIS

FROM:
Montana Testing Laboratories, Inc
P. O. Box 2013
Great Falls, Montana 59401

FOR: (Grower) Western Energy
HELDT

CLIENT: (Dealer)

Lab No	Your Field No.	Depth (Inches)	pH	Organic Matter %	Nitrate Nitrogen ppm	Lbs./Ac. N	Phosphorus P ppm	Potassium K ppm	Calcium Ca meq/100g	Magnesium Mg meq/100g	Sodium Na meq/100g	Salt Hazards mmhos	Soil Texture	[illegible]
														LIME
9106		0-6	8.3	2.7	1.85	3.7	14.5	213	7.5	3.2	0.1	0.4	FSL	M
9107		6-22	8.4	1.2	0	0	62.0	88	19.4	3.0	0.1	0.3	L+	M+
9108		22-34	8.5	0.6	0	0	12.5	88	+35	7.3	0.1	0.5	SiL	M+
9109		34-44	8.6	0.08	0	0	12.5	43	29.3	9.2	0.1	0.9	L	M
9110		44-64	8.3	0.08	0	0	21.0	43	29.3	6.2	0.5	2.9	SiL	0

OTHER TESTS REQUIRED

Sulfur ppm	Zinc ppm	Iron ppm	Copper ppm	Manganese ppm	Boron ppm	0.3 ATM	15 ATM	Lime or Gypsum	Cation Exchange Capacity (CEC)	Mechanical Analysis % Clay	Mechanical Analysis % Silt	Mechanical Analysis % Sand	~~Others~~
								SAR					texture
	0.05	4.0	1.6	10.8		19.[illegible]	[illegible]	2.77		30.8	30.4	38.8	CL
	0	4.6	1.8	4.8		17.26	8.63	0.33		28.8	20.4	52.8	SCL
	0	5.2	2.0	3.6		19.5	9.75	0.32		32.8	26.4	40.8	CL
	0	7.0	1.6	2.8		13.38	9.19	1.22		30.8	24.4	44.8	SCL
	0	4.9	1.4	2.4		11.42	5.71	0.72		16.8	28.4	64.8	SL

HELDT SERIES

The Heldt Series consists of deep, well drained calcareous soils formed in alluvium. They occupy fans. Slopes range from two to eight percent. Annual precipitation is ten to 14 inches.

In a representative profile the surface layer is grayish-brown silty clay loam about six inches thick. The subsoil is light grayish brown silty clay loam about 16 inches thick. The underlying material is pale brown heavy loam or clay loam.

Permeability is slow and runoff is medium.

Typifying Pedon

Heldt silty clay loam, 2 to 8 percent slope:

A1 0-6 inches, dark grayish-brown (10yR 4/2) moist; silty clay loam; moderate fine granular structure; slightly hard when dry, friable when moist; and sticky when wet.

B2 6-22 inches, grayish-brown (10yR 5/2) moist; silty clay loam; coarse blocky structure; hard when dry, friable when moist; and sticky when wet; strong effervescence; small nodules and fine threads of segregated lime.

C1 22-34 inches, pale-brown (10yR 6/3) moist; heavy loam; massive; hard when dry, driable when moist and slightly sticky when moist; strong effervescence.

C2 34-44 inches, pale-brown (10yR 6/3) moist; heavy loam; massive; hard when dry; friable when moist and slightly sticky when wet; strong effervescence.

C3 44-60 inches; brown (10yR 5/3) moist; sandy loam; massive; slightly hard when dry, very friable when moist and non-sticky when wet; strong effervescence.

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Date Rec'd. 8-27-73

Date Sent

RESULTS OF
DEEP SOIL SAMPLE ANALYSIS

FROM:
Montana Testing Laboratories, Inc.
P. O. Box 3048
Great Falls, Montana 59404

FOR: (Grower) Western Energy
Area A1 Stop 8 Hvg

CLIENT: (Dealer)

Lab No.	Your Field No.	Depth (Inches)	pH	Organic Matter %	Nitrate Nitrogen ppm	Lbs./Ac. N	Phosphorus P ppm	Potassium K ppm	Calcium Ca meq/100g	Magnesium Mg meq/100g	Sodium Na meq/100g	Salt Hazards mmhos	Soil Texture	[illegible]
														LIME
8726	36	0-6	7.9	1.3			4.3	275	18.1	3.0	0.1	0.4	L	S
8727	37	6-17	7.6	1.9			1.8	300	22.4	5.3	0.1	0.4	SiL+	S
8728	38	17-24	7.8	1.4			1.5	213	25.9	8.0	0.1	0.5	L+	S
8729	39	24-36	8.1	0.1			1.8	113	+35	13.1	0.1	0.4	L	M
8730	40	36-54	8.3	0.1			10.0	88	+35	12.6	0.1	0.6	L	M+
8731	41	54-6	8.2	0.1			1.8	88	30.7	7.8	0.1	0.8	FSL	M

OTHER TESTS REQUIRED

TEXTURES

Sulfur ppm	Zinc ppm	Iron ppm	Copper ppm	Manganese ppm	Boron ppm	0.3 ATM	15 ATM	Lime or Gypsum	Cation Exchange Capacity (CEC)	Mechanical Analysis % Clay	% Silt	% Sand	[illegible]
								SAR					
42.9	0.1	10.6	2.8	4.8		5.66	2.83			8.8	26.4	64.8	SL
8.5	0.1	11.9	2.6	3.6		6.0	3.0			26.8	22.4	50.8	SCL
4.7	0.22	9.8	2.4	3.2		6.85	3.42			10.8	36.4	52.8	SL
68.2	0.45	19.0	2.6	10.2		14.92	7.46			24.8	12.4	62.8	SCL
70.1	0.22	18.0	2.9	5.4		9.12	4.56			14.8	20.4	64.8	SL
84.7	0.1	14.0	2.5	4.8		9.12	4.56			14.8	12.4	72.8	SL

Ind.-Obs. 2370 5000

Haverson loam, 0 to 2 percent slopes (Hvg). This soil is found on nearly leveled flood plains along drainages. It has the typical profile for the series.
Risk of erosion is slight for water and moderate for wind.

Recommendations for Stockpiling:

This soil is suitable for stockpiling to a depth of at least 5 feet or below as deep as the underlying material remains basically the same. The water table at some depth greater than 5 feet generally occurs in this soil.

HAVERSON SERIES

The Haverson Series consists of deep, well-drained, calcareous soils formed in alluvium. They occupy flood plans along drainages and on fans. Slopes range from 0 to 8 percent. Annual precipitation is 10 to 14 inches.

In a representative profile, the surface layer is grayish-brown loam about 6 inches thick. The substratum is light brownish-gray and grayish-brown loam stratified with loamy fine sand.

Permeability is moderate and runoff is slow on the nearly level flood plains and medium on the fans.

Typifying Pedon:

Typical profile of Haverson loam:

Alp-0-6 inches, grayish-brown (2.5y 5/2) loam, dark grayish-brown (2.5y 4/2) moist; moderate fine crumb structure; slightly hard, very friable, nonsticky and slightly plastic; weak effervescence; abrupt wavy boundary.

A12-6-17 inches, grayish-brown (3.5y 5/2) silt loam, very dark grayish-brown (2.5y 4/2) moist; very weak fine and medium subangular blocky structure; slightly hard, friable, slightly sticky and slightly plastic; common fine and very fine roots; many fine and very fine pores; strong effervescence; clear smooth boundary.

C1-17-24 inches, grayish-brown (2.5y 5/2) loam, very dark grayish-brown (2.5y 3/2) when moist; massive; hard, friable, slightly sticky and slightly plastic; common fine and very fine pores; strong effervescence; few fine threads of lime; clear wavy boundary.

C2-24-52 inches, light brownish-gray (2.5y 6/3) loam, grayish-brown (2.5y 5/3) moist; massive; hard, very friable, nonsticky and slightly plastic; common very fine roots; many fine and very fine pores; strong effervescence; clear boundary.

C3-52-66 inches, light brownish-gray (2.5y 6/3) loamy fine sand, olive brown (2.5y 4/4) moist; massive; very friable, nonsticky and nonplastic; few fine and very fine roots; strong effervescence.

Table 5 Chemical Properties of Horizon Samples Associated with Coal Areas
Western Energy Area B

Sample # 3 Fort Collins Loam

Lab No.	Horizon	Depth inches	pH Paste	Sat'n. %	Elect. Cond. mmhos/cm	Saturation Extract Cations Ca meq/liter	Mg meq/liter	Na meq/liter	SAR
7802	Ap	0-6	6.7	34.0	0.7	1.25	1.98	0.48	0.38
7803	B2t	6-16	7.1	40.5	0.8	2.13	2.08	0.69	0.48
7804	B3	16-21	7.8	38.2	0.5	1.63	2.29	1.00	0.68
7805	C1ca	21-27	8.1	37.1	1.1	2.50	8.96	2.30	0.99
7806	C2	27-62	8.1	33.3	0.5	1.88	3.13	1.30	0.83

Table 6 Results of Mechanical Analysis (Hydrometer Method) with Micro Nutrients (DTPA Zn, Fe, Cu, Mn) and Boron

Depth inches	Mechanical Analysis Clay %	Silt %	Sand %	Texture	Zn ppm	Fe ppm	Cu ppm	Mn ppm	B ppm
0-6	17.2	13.2	69.6	SL	0.9	11.5	1.8	12.8	0.6
6-16	23.6	18.4	58.0	SL	0.02	8.4	1.6	6.7	0.5
16-21	28.4	20.8	50.8	SCL	0.2	8.4	1.6	6.7	0.3
21-27	21.2	21.6	57.2	SCL	0.04	4.6	1.6	1.8	0.7
27-62	14.8	12.0	73.2	SL	0.04	3.0	1.4	1.0	0.2

FORT COLLINS SERIES

The Fort Collins series consists of deep, well drained soils formed from alluvium washed from soft sandstone, loam and siltstone uplands. They occupy fans and footslopes. In a representative profile the surface layer is grayish brown loam about six inches thick. The subsoil is grayish brown to olive gray clay loam about 14 inches thick. Below this is calcareous olive and pale olive loam to 60 or more inches. Slopes are four to eight percent. The permeability is moderate and runoff is medium.

Typifying Pedon

Fort Collins Loam, Five Percent Slope

A_1 0-4 inches, graying brown (2.5Y 5/2) loam, very dark grayish brown (2.5Y 3/2) moist; moderate, very thin platy structure; hard, friable, slightly sticky and plastic; common fine and very fine roots; clear, smooth boundary.

B_1 4-6 inches, grayish brown (2.5Y 5/2) light clay loam, dark grayish brown (2.5Y 4.2) moist; moderate, coarse prismatic structure; hard, friable, sticky and plastic; common fine and very fine roots; clear, wavy boundary.

B_{2t} 6-14 inches, grayish brown (2.5Y 5/3) clay loam, olive brown (2.5Y 4/3) moist; moderate, medium and coarse prismatic structure parting to moderate, medium blocks; very hard, firm, very sticky and plastic; common fine and very fine roots; gradual, wavy boundary.

B_3 14-20 inches, pale olive (5Y 6/3) light clay loam, olive (5Y 5/3) moist; weak, medium prismatic structure parting to weak, medium blocks; very hard, firm, sticky and plastic; weak effervescence; a few fine lime mottles; a few very fine roots; clear, wavy boundary.

C_{1ca} 20-25 inches, pale yellow (5Y 7/3) light loam, pale olive (5Y 6/4) moist; massive; hard, friable, sticky and plastic; strong effervescence, common fine lime mottles; a few very fine roots; gradual, wavy boundary.

C_2 25-60 inches, pale olive (5Y 6/3) light loam, olive (5Y 5/4) moist; massive; hard, friable, slightly sticky and plastic; strong effervescence; a few fine lime mottles; a few very fine roots.

Location: 400' S and 85' W of ¼ corner, Sec. 8 & 9; T1N, R41E.

Laboratory Sample #5

Texture in the upper three feet ranges from light loam to heavy clay loam. At depths below three feet, stratification includes textures of silt loam and fine sandy loam.

Date Rec'd.
Date Sent

RESULTS OF
DEEP SOIL SAMPLE ANALYSIS

FROM:
Montana Testing Laboratories,
P. O. Box [illegible]
Great Falls, Montana [illegible]

FOR: [illegible]
(Grower)
Area [illegible] Stop 15 Elso

CLIENT:
(Dealer)

Lab No.	Your Field No.	Depth Inches	pH	Organic Matter %	Nitrate Nitrogen ppm	Lbs./Ac. N	Phosphorus P ppm	Potassium K ppm	Calcium Ca meq/100g	Magnesium Mg meq/100g	Sodium Na meq/100g	Salt Hazard mmhos	Soil Texture	[illegible]
/ 9019		0-5	8.0	1.4	0.25		7.7	188	28.9	3.4	0.1	0.4	L	M
9020		5-11	8.2	1.2	1.25		[illegible]	150	29.0	3.2	0.1	0.4	L	M+
9021		11-29	8.1	1.1	0.5		33.5	113	24.5	5.0	0.3	0.7	VFSL	M+

OTHER TESTS REQUIRED

Sulfur ppm	Zinc ppm	Iron ppm	Copper ppm	Manganese ppm	Boron ppm	0.3 ATM	15 ATM	Lime or Gypsum	Cation Exchange Capacity (CEC)	Mechanical Analysis % Clay	Mechanical Analysis % Silt	Mechanical Analysis % Sand	Others
1.4	0	4.6	1.8	10.2		10.32	5.16			16.8	42.4	40.8	L
6.1	0	5.8	1.6	5.2		9.14	4.57			14.8	46.4	38.8	L
105	0	5.5	1.2	3.6		10.28	5.14			16.8	4.4	78.8	SL

ELSO SERIES

The Elso Series consists of shallow, well-drained soils formed from weathered sandstone and siltstone. They occupy uplands and are underlain by sandstone and siltstone in depths of 6 to 20 inches. Annual precipitation is 10 to 14 inches.

In a representative profile the surface layer is light brownish-gray calcareous loam about 5 inches thick. Below this is a light gray loam about 6 inches thick that merges with soft sandstone and siltstone at a depth of about 11 inches. Slopes are 10 to 50 percent.

Permeability is moderate and moderately slow, and runoff is moderately rapid.

Typifying Pedon:

Typical profile of Elso loam:

A1-0-5 inches, light brownish-gray (2.5y 6/2) loam, grayish-brown (2.5y 5/2) moist; moderate fine granular structure; soft, very friable, nonsticky and nonplastic; weak effervescence; clear wavy boundary.

C1-5-11 inches, light-gray (2.5y 7/3) loam, light yellowish-brown (2.5y 6/3) moist; moderate medium platy structure; slightly hard, very friable, nonsticky and nonplastic; many fine and very fine pores; strong effervescence; clear wavy boundary.

C2-11-28 inches, white (2.5y 8/2) very soft platy siltstone that rubs to silt loam, light brownish-gray (2.5y 6/2) moist; few fine and very fine roots; strong effervescence.

Recommendations for Stockpiling:

All the soil material above the soft shale siltstone in the Elso loam part of this complex is suitable for stockpiling. The soil depth is approximately 1 foot, but locally can be less than 1 foot or nearly as much as 2 feet. The underlying soft shale and siltstone is undesirable for stockpiling because of slow rate of water intake.

[illegible]
[illegible]

RESULTS OF
DEEP SOIL SAMPLE ANALYSIS

Montana Testing Laboratories
P. O. Box [illegible]
Great Falls, Montana [illegible]

FOR: (Grower) Western Energy
Area 11 Stan 18 Sa Cushman

CLIENT: (Dealer)

Lab No.	[illegible]	[illegible]	pH	Organic Matter %	Nitrate Nitrogen ppm	Lbs./Ac. N	Phosphorus P ppm	Potassium K ppm	Calcium Ca meq/100g	Magnesium Mg meq/100g	Sodium Na meq/100g	Salt Hazard mmhos	Soil Texture	[illegible]
9005		0-6	7.6	1.6	10.4		29.5	150	27.5	3.2	0.1	0.5	L	[illegible]
9006		6-15	7.7	1.0	4.5		12.5	113	32.4	3.8	0.1	0.4	L	M+
9007		15-30	8.0	0.08	1.25		2.5	42	9.5	8.5	0.1	0.4	L-	M+
9008		30-58	8.2	0.08	2.5		7.7	63	30.7	11.7	0.1	0.3	FSL	M+
9009		58-72	7.9	0.2	4.5		5.0	275	8.8	5.0	0.1	0.3	L-	M+

OTHER TESTS REQUIRED

Sulfur ppm	Zinc ppm	Iron ppm	Copper ppm	Manganese ppm	Boron ppm	0.3 ATM	15 ATM	Lime or Gypsum	Cation Exchange Capacity (CEC)	Mechanical Analysis % Clay	Mechanical Analysis % Silt	Mechanical Analysis % Sand	Others
1.4	0	5.5	1.8	10.8		10.93	5.47			17.8	6.4	75.8	SL
0.7	0	3.2	1.4	4.4		11.45	5.72			18.8	40.4	40.8	L
2.8	0	5.2	1.4	3.6		14.8	7.4			24.8	32.4	42.8	L
80.3	0	6.6	1.4	2.8		13.71	6.83			22.8	46.4	30.8	L
+138	0.3	4.4	1.1	1.8		15.4	7.7			25.8	15.4	58.8	SCL

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Date Rec'd.

Date Sent

RESULTS OF DEEP SOIL SAMPLE ANALYSIS

FROM:

Montana Testing Laboratories, Inc.
P. O. Box 3043
Great Falls, Montana 59403

FOR: (Grower) Western Energy

Area A1 Step 19 Ca Cushman

CLIENT: (Dealer)

Lab No.	Your Field No	Depth (Inches)	pH	Organic Matter %	Nitrate Nitrogen ppm	Lbs./Ac. N	Phosphorus P ppm	Potassium K ppm	Calcium Ca meq/100g	Magnesium Mg meq/100g	Sodium Na meq/100g	Salt Hazards mmhos	Soil Texture	Available H2O (Inches)
														LIME
8999		0-6	6.5	0.08	1.85		5.0	350	18.5	5.0	0.3	0.4	L	S
9000		6-8	6.7	0.03	0.25		7.7	238	21.1	5.3	0.1	0.4	L	S
9001		8-18	7.2	0.8	0.25		2.5	63	+35	4.5	0.1	0.4	L	M+
9002		18-24	7.6	0.08	0.25		17.5	88	33.3	4.8	0.1	0.3	FSL	M+
9003		24-38	7.7	0.08	0.5		2.5	2.5	+35	8.0	0.1	0.4	FSL	M+
9004		38-50	7.9	0.08	0.5		5.0	2.5	32.0	5.9	0.1	0.4	FSL	M+

OTHER TESTS REQUIRED

Sulfur ppm	Zinc ppm	Iron ppm	Copper ppm	Manganese ppm	Boron ppm	0.3 ATM	15 ATM	Lime or Gypsum	Cation Exchange Capacity (CEC)	Mechanical Analysis % Clay	% Silt	% Sand	Others
													Texture
0.7	0	6.6	1.6	13.8		13.71	6.85			22.8	20.4	56.8	SCL
4.1	0	11.5	1.6	9.2		10.16	5.08			16.8	30.4	62.8	SCL
0.7	0	7.8	1.4	5.4		14.89	7.44			24.8	28.4	56.8	SCL
0.7	0	6.3	1.4	2.8		10.16	5.08			16.6	6.8	78.6	SL
43.4	0	6.0	1.2	5.2		7.85	3.92			12.8	5.4	81.8	LS
59.4	0	10.0	1.1	13.1		10.16	5.08			16.8	6.4	78.8	SL

Ind.-Obs. 2570 [illegible]

C2-24-48 inches, light yellowish-brown (2.5y 6/3) fine sandy loam, light olive-brown (2.5y 5/4) moist; massive; hard, very friable, non-sticky and non-plastic; few very fine roots; common fine and very fine pores; strong effervescence.

C3-38-50 inches, pale-brown, soft, shattered, well-weathered sandstone and residual loamy fine sand; sandstone fragments are undercoated with lime.

Cushman loam, 2 to 8 percent slopes (Ca). This soil is located on gently and moderately sloping uplands. The profile is typical for the series.

Risk of erosion is moderate for water and slight for wind.

Recommendations for Stockpiling:

The top 3 feet of soil are well suited for stockpiling. Locally the material is suitable to a depth of 4 to 6 feet. It is easily worked, has high natural fertility and roots penetrate well. The underlying soft sandstone and loamy shale is undesirable for stockpiling because of slow infiltration and slow internal permeability.

CUSHMAN SERIES

The Cushman Series consists of moderately deep, well-drained soils formed from weathered soft sandstone and siltstone. They occupy uplands and are underlain by sandstone and siltstone, at depths of 20 to 40 inches.
Annual precipitation is 10 to 14 inches.

In a representative profile the surface layer is grayish-brown loam about 6 inches thick. The subsoil is brown clay loam about 2 inches thick. Below this lies a calcareous loam which grades to fine sandy loam. This merges with soft sandstone and shale at about 38 inches. Slopes are 2 to 8 percent.

Permeability is moderate and runoff is medium.

Typifying Pedon:

Typical profile of Cushman loam, 2 to 8 percent slopes:

Ap-0-6 inches, light brownish-gray (2.5y 5/2) loam, dark grayish-brown (2.5y 4/2) moist; moderate fine crumb structure; soft when dry, very friable when moist and nonsticky and nonplastic when wet; clear wavy boundary.

B2t-6-8 inches., brown (10yR 5/3) clay loam, dark brown (10yR 4/3) moist; moderate medium prisms that separate to moderate medium and fine subangular blocks; hard, friable, sticky and plastic; clay films on pads; common fine and very fine roots; many fine and very fine pores; no effervescence; clear wavy boundary.

B3ca-8-18 inches, light gray (2.5y 7/2) heavy loam, olive brown (2.5y 4/3) moist; weak coarse plates that separate to moderate medium and fine subangular blocks; hard, friable, slightly stick and slightly plastic; common fine and very fine roots; many fine and very fine pores; strong effervescence; common films of lime; clear wavy boundary.

Clca-18-24 inches, light gray (2.5y 7/3) fine sandy loam, light olive brown (2.5y 5/4) moist; massive; very hard, very many fine and very fine pores; strong effervescence; many fine filsm.and threads of lime; diffused boundary.

BAINVILLE SERIES

The Bainville series consists of moderately deep, well drained soils formed in place from weathered, soft shale and sandstone. They occupy uplands having slope range of four to 75 percent.

In a representative profile the surface layer is light olive gray loam about two inches thick. The substratum is light olive gray to pale olive loam or silt loam. The soil rests on shoft shale at about 22 inches.

Typifying Pedon

A_1 0-2 inches, light olive gray (5Y 6/2) loam, olive (5Y 4/3) moist; weak, fine crumb structure; slightly hard, friable; slightly sticky and slightly plastic; many fine roots; clear, wavy boundary.

C_1 2-9 inches, light olive gray (5Y 6/2) loam, olive (5Y 4/3) moist; weak, fine and medium blocky structure; hard, friable, sticky and plastic; weak effervescence; common fine roots; five percent of volume is shale and sandstone chips; gradual, wavy boundary.

C_2 9-22 inches, pale olive (5Y 6/3) heavy silt loam, olive (5Y 5/3) moist; weak, coarse prismatic structure; hard, friable, sticky and plastic; strong effervescence; common coarse lime mottles; ten percent of volume is flat shale chips; irregular boundary.

CR 22+ inches, platy shale and sandstone.

Location: 350' W & 250' N of ¼ corner Sec. 9 & 10; T1N, R41E.

Laboratory Sample #4

Depth to shale ranges from 20 to 36 inches. Coarse fragments cover zero to 25 percent of the surface. The profile contains zero to 60 percent coarse fragments of shale and sandstone with greatest concentrations immediately above the bedrock.

APPENDIX B-1

SOIL DESCRIPTIONS AND SOIL TEST DATA

CONTENT

Soil Series Descriptions and Analyses Results for Rosebud Mine Areas A and E, Colstrip, Montana

TABLE 4

AVERAGE EMISSION RATES FOR HEAVY-DUTY DIESEL-POWERED AND GASOLINE-POWERED CONSTRUCTION EQUIPMENT (grams per second - U.S. EPA, 1976)

	Carbon Monoxide	Exhaust Hydro-carbons	Nitrogen Oxides (NO_2)	Sulfur Oxides (SO_2)	Particulates
Diesel-Powered					
Tracklaying tractor	< 0.1	< 0.1	0.2	< 0.1	< 0.1
Wheeled tractor	0.3	< 0.1	0.1	< 0.1	< 0.1
Wheeled dozer	0.1	< 0.1	0.6	< 0.1	< 0.1
Scraper	0.2	0.1	0.8	0.1	0.1
Motor grader	< 0.1	< 0.1	0.1	< 0.1	< 0.1
Wheeled loader	0.1	< 0.1	0.3	< 0.1	< 0.1
Tracklaying loader	< 0.1	< 0.1	0.1	< 0.1	< 0.1
Off-highway truck	0.2	0.1	1.0	0.1	< 0.1
Roller	< 0.1	< 0.1	0.1	< 0.1	< 0.1
Miscellaneous	0.1	< 0.1	0.3	< 0.1	< 0.1
Gasoline-Powered					
Wheeled tractor	1.2	< 0.1	0.1	< 0.1	< 0.1
Motor grader	1.5	0.1	< 0.1	< 0.1	< 0.1
Wheeled loader	2.0	0.1	0.1	< 0.1	< 0.1
Roller	1.7	0.1	< 0.1	< 0.1	< 0.1
Miscellaneous	2.1	0.1	0.1	< 0.1	< 0.1

TABLE 3

FEDERAL PRIMARY AND SECONDARY AIR QUALITY STANDARDS[a]

Pollutant	Averaging Time	Federal Primary Standard	Federal Secondary Standard
Nitrogen Dioxide[b]	Annual Average	0.05 ppm[c] (100 μg/m^3)[d]	0.05 ppm (100 μg/m^3)
Sulfur Dioxide	Annual Average	0.03 ppm (80 μg/m^3)	-
	24 Hour	0.14 ppm (365 μg/m^3)	-
	3 Hour	-	0.05 ppm (1300 μg/m^3)
Suspended Particulate	Annual Geometric Mean	75 μg/m^3	60 μg/m^3
	24 Hour	260 μg/m^3	150 μg/m^3
Hydrocarbons (corrected for methane)	3 Hour 6:00-9:00 a.m.	0.24 ppm[e] (160 μg/m^3)	0.24 ppm (160 μg/m^3)
Photochemical Oxidants	1 Hour	0.08 ppm (160 μg/m^3)	0.08 ppm (160 μg/m^3)
Carbon Monoxide	8 Hour	9 ppm (10 mg/m^3)[f]	9 ppm (10 mg/m^3)
	1 Hour	35 ppm (40 mg/m^3)	35 ppm (40 mg/m^3)

All standards except annual average are not to be exceeded more than once a year.

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[a] From the Bureau of National Affairs, 1975.

[b] Nitrogen dioxide is the only one of the nitrogen oxides considered in the ambient standards.

[c] ppm = parts per million

[d] μg/m^3 = micrograms per cubic meter

[e] Maximum 3-hour concentration between 6:00 - 9:00 a.m.

[f] mg/m^3 = milligrams per cubic meter

TABLE 2

Sheet 2 of 2

Pollutants	Standards (Maximum permissible concentrations
Total suspended particulate	75 micrograms per cubic meter of air, annual geometric mean 200 micrograms per cubic meter of air, not to be exceeded more than 1 percent of days a year
Settleable particulate (dustfall)	15 tons per square mile per month, 3-month average in residential areas 30 tons per square mile per month, 3-month average in heavy industrial areas
Lead	5.0 micrograms per cubic meter of air, 30-day average
Beryllium	0.01 micrograms per cubic meter of air, 30-day average
Fluorides, total (as HF) in air	1 part per billion parts of air, 24-hour average
Fluorides (as F) in forage for animal consumption - dry weight basis	35 parts per million
Fluorides (gaseous)	0.3 micrograms per square centimeter per 28 days

TABLE 2 Sheet 1 of 2

STATE OF MONTANA AMBIENT AIR QUALITY STANDARDS[a]

Pollutants	Standards (Maximum permissible concentrations)
Sulfur dioxide	0.02 ppm, maximum annual average 0.10 ppm, 24-hour average, not to be exceeded over 1 percent of the days in any 3-month period 0.25 ppm not to be exceeded for more than 1 hour in any 4 consecutive days
Reactive sulfur (sulfation)	0.25 milligrams sulfur trioxide per 100 square centimeters per day, maximum annual average 0.50 milligram sulfur trioxide per 100 square centimeters per day, maximum for any 1-month period
Suspended sulfate	4 micrograms per cubic meter of air, maximum allowable annual average 12 micrograms per cubic meter of air, not to be exceeded over 1 percent of the time
Sulfuric acid mist	4 micrograms per cubic meter of air, maximum allowable annual average 12 micrograms per cubic meter of air, not to be exceeded over 1 percent of the time 30 micrograms per cubic meter of air, hourly average, not to be exceeded over 1 percent of the time
Hydrogen sulfide	0.03 ppm, 1/2-hour average, not to be exceeded more than twice in any 5 consecutive days 0.05 ppm, 1/2-hour average, not to be exceeded over twice a year

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[a] From The Bureau of National Affairs, 1975

is undoubtedly extremely small. This events' influence is demonstrated by the fact that the five year growing season averages which contain the year 1944 rank one through five out of forty-four. A precipitation event of this magnitude has obvious erosion potential.

3. The cyclic nature of the Crow Agency precipitation record is further demonstrated by the fact that the lowest five year growing season averages (rank 75-80) are all in the 1930's.

4. The drought of the 1930's was accompanied by a disproportionate decrease in growing season precipitation. Average precipitation for the period 1930-1939 was 87% of the average for the period of record at Colstrip, Montana. However, the average growing season precipitation for the same period was only 77% of the average for the period of record.

5. The similar nature of the climatic record of Colstrip and Crow Agency is evidenced by the fact that their Thornthwaite P.E. Index values are essentially identical.

It should be noted that the climatic analyses performed here are preliminary in nature and represent only a very beginning of the regional climatic analysis that should be performed. The cyclic nature of the climatic record of Eastern Montana should be explored in much more detail. Considerable effort has been expended in the last few years to project levels of coal mining and energy conversion development in Eastern Montana. A similar effort should now be undertaken to determine the potential for reclamation success in various locations and the influence of climate and climatic cycles on such success.

An analysis of the precipitation record for Colstrip and Crow Agency, Montana, a preliminary report to the Montana Department of State Lands, Helena, MT, unpublished manuscript, Dept. of Geology, University of Montana. by John R. McBride, 1976.

For Colstrip Montana continuous monthly and annual precipitation data exist for the period 1928-1974. Annual, growing season (April-September), five year average annual, and five year average growing season precipitation frequency probability plots were calculated for these data. These plots permit the determination of the probability of occurrence of a given precipitation quantity. In addition, similar calculations were performed for the precipitation record of Crow Agency, Montana. Since Crow Agency has a precipitation record dating back to 1879 and is climatically similar to Colstrip, this record is particularly valuable in assessing the climate prior to the installation of precipitation measuring equipment at Colstrip, Montana. Finally, a Thornthwaite potential evapotranspiration index was calculated for several stations in Southeastern Montana to further define the nature of the Climate in the Colstrip vicinity.

The following observations can be made based on a preliminary review of the above calculations:

1. The recent reclamation efforts in Eastern Montana have indeed taken place during an unusually optimum moisture phase. For the precipitation record at Colstrip, Montana, the past five years' average precipitation ranks fourth out of forty-four (probability of occurrence less than one in ten). The average growing season precipitation at Colstrip for the last five years ranks fifteenth out of forty-four. The "optimum" nature of recent precipitation is much more strikingly shown in the Crow Agency record. The average annual precipitation for the last five years at Crow Agency ranks second out of seventy-four (probability of occurrence less than one in thirty-three). The five year average growing season precipitation in the recent past is the highest on record. The period 1968-1972 ranks first out of eighty, 1967-1971 ranks second, 1969-1973 ranks third, 1964-1968 is fourth, 1971-1975 is fifth, 1964-1968 is sixth, 1966-1970 is tied for ninth, and 1965-1969 is eleventh.

2. Unusually large precipitation events have also occurred in the coal regions of Southeastern Montana. In fact, the "optimum" nature of current precipitation conditions at Colstrip is partially masked due to the influence of a single months' precipitation. In June, 1944 10.28 inches of rain fell at Colstrip, Montana. The growing season precipitation total for 1944 was 21.34 inches, almost twice the average for the period of record. The probability of occurrence of an event of this magnitude has not yet been calculated, but it

TABLE 1

MEAN EVAPORATION (INCHES)[a]
TERRY, MONTANA

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Yr
Mean Evaporation	-	-	-	-	8.51	9.93	10.91	9.59	5.99	-	-	-	-
Years of Record					5	7	9	9	10				

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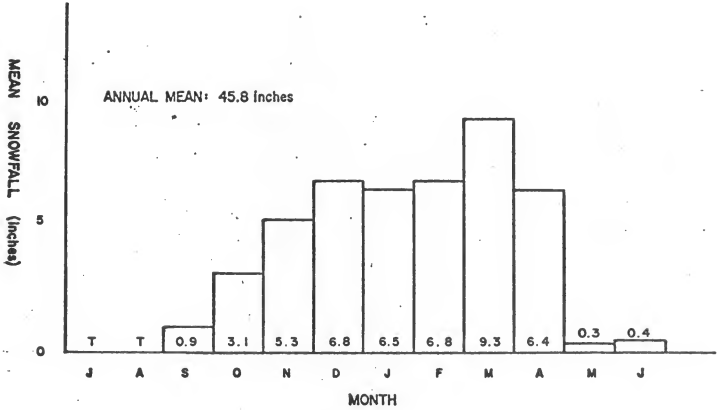
[a] U.S. Department of Commerce, 1965

Figure 1

MEAN MONTHLY SNOWFALL
Colstrip, Montana[a]

(From U. S. Department of Commerce, 1965)



[a] BASED ON RECORDS FROM 26–29 YEARS PRIOR TO AND INCLUDING 1960

NRIS 57

APPENDIX A

CLIMATE AND AIR QUALITY

CONTENT

An Analysis of the Precipitation Record for Colstrip and Crow Agency, Montana, by John R. McBride

Figure 1. Mean Monthly Snowfall - Colstrip, Montana
Table 1. Mean Evaporation - Terry, Montana
Table 2. State of Montana Ambient Air Quality Standards
Table 3. Federal Primary and Secondary Air Quality Standards
Table 4. Average Emission Rates for Heavy-Duty Diesel-Powered and Gasoline-Powered Construction Equipment

APPENDIX B-2

OVERBURDEN ANALYSES - MINE AREAS A AND E

SOIL TOXICITIES

Chemical constituents of primary interest in the overburden are the concentrations of salts, sodium, and trace elements. The primary concern is to identify layers which are potentially toxic to plant growth or to animal consumption of plant material.

A salt hazard is normally considered to occur at an electrical conductivity (ECe) of 4 mmhos/cm in the saturation extract. At this level of salt concentration, the yield of salt sensitive plants is reduced. Conductivity levels are grouped by classes up to 16 mmhos/cm; in the highest only the most salt sensitive plants will grow.

High levels of sodium in soils have a significant detrimental effect on soil tilth. Sodium is a potentially toxic element at high concentrations, and may cause a deficiency in calcium uptake by plant tissue. However, sodium occurs most commonly at levels not detrimental to soil structure. At higher concentrations, soil structure breaks down, soil permeability is sharply decreased and cultivation is difficult. Sodium adsorption ratio (SAR) values of 10-12 or Exchangeable Sodium Percentage (ESP) values of 10-12 are indications of high sodium concentrations. These values are not directly applicable in terms of their effects on all soils because other factors such as absolute ion concentrations, soil texture, and clay mineral content affect soil structure as well.

GREAT FALLS • BILLINGS MONTANA • BOISE IDAHO • GILLETTE WYOMING

Report of: Analysis & Interpretations of Overburden
& Innerburden Samples Test Data
Western Energy Colstrip Mine

Date March 23, 1976
Job Number 69-147
Sheet 1 of 6

Report to: WESTERN ENERGY COMPANY (4)
ATTENTION MR MIKE GRENDE
40 EAST BROADWAY
BUTTE MT 59701

Sample Identification:

On December 8 & 22, 1975, and January 23, 1976, samples of overburden and innerburden were delivered to our laboratory for analysis and interpretation of the data. The results of the analyses were reported to you on January 9, 1976 and February 17 and 24, 1976. Copies of reports are enclosed.

TEST RESULTS:

The summary of the analysis is presented on the enclosed Tables. The narrative interpretation of the data was prepared by Dr. Vincent A. Haby, working with our staff, and he has approved the enclosed report.

cc: Dr. Vincent A. Haby
Southern Agricultural Research Center
Huntley, Montana 59037

Certified Leland J.

REPORT
OF
INTERPRETATION OF THE ANALYSIS OF OVERBURDEN & INNERBURDEN SAMPLES AS RELATED TO THE DISPOSAL OF STRIPPED MATERIALS AND REVEGETATION OF SURFACE MINED AREAS

WESTERN ENERGY COAL MINE, COLSTRIP, MONTANA

INTRODUCTION

The object of this investigation was to determine the levels of potentially toxic materials present in the overburden, and provide for the revegetation of the mined areas.

METHODS AND MATERIALS

Overburden and innerburden samples were collected and submitted by Western Energy Company to us for analysis. The procedures used for chemical and physical analysis are those recommended by the Department of State Lands in the tentative guidelines for the Montana Strip Mining and Reclamation Act. All data from the analyses are summarized on the enclosed Tables.

This interpretation includes a discussion of the analytical data, indicating drill holes and depths at which the data indicate a particular element exceeds levels acceptable for revegetation. A summary of the drill holes and depths at which unacceptable overburden material occurs, and another showing the acceptable materials, is included.

RESULTS AND DISCUSSION

This report includes two Tables, which point out critical and desirable chemical and physical properties of the 13 drill holes. Observation of test results at these 13 locations indicate that the pH, nitrate-nitrogen, boron, selenium, molybdenum, mercury, iron, manganese, and copper levels were lower than the suggested maximum limits set forth by the Montana Department of State Lands. Therefore, these elements have been omitted from Tables 1 and 2.

The purpose of Table 1 is to establish the location and depths at which overburden and innerburden materials contain suspect levels of chemical and/or physical properties (as established by the Montana Department of State Lands) which could interfere with revegetation of strip mined and regraded areas.

A conductivity level of 4.0 millimhos was used to differentiate between slightly saline and moderately saline conditions. However, since salinity affects plant growth by degree, and plants differ in their susceptibility to salts, deviations in conductivity up to 7 or 8 mmhos could possibly be tolerated if the proper plants are selected for revegetation.

Table 2 presents overburden soils which are the most suitable for revegetation of the mined and regraded areas. At all but three of the 13 drill holes, it is possible to use the surface soils, or a thorough mixture of the Rosebud overburden, for reclamation. Alternatives are suggested at these locations.

RECOMMENDATIONS

As noted in Table 1, zones in the Rosebud seam overburden contain potentially toxic chemical and/or physical properties, which, if not carefully considered during mining, could interfere with successful revegetation. The alternate recommendations below are offered for consideration. Each drill hole is treated independently, and care has been taken to provide feasible alternatives for the mixing or disposal of potentially toxic materials.

Should it become necessary to mine the McKay coal, it is recommended that the Rosebud-McKay innerburden be buried at the bottom of the pit, as this soil contains toxic, or nearly toxic, levels of several micronutrients in all the drill holes tested.

Drill Hole: N47000, E44000

The best overburden materials available to place under the topsoil are the intervals from 0 to 5 and 20 to 32 feet. However, if the overburden above the Rosebud seam is thoroughly mixed during the stripping process, the average composition of the mixture will fall below the levels considered suspect, and will be suitable for placement under the topsoil.

Drill Hole: N47000, E46000

The best overburden material available to place under the topsoil is the 0 to 15 foot depth. However, if the overburden above the Rosebud seam is thoroughly mixed during the stripping process, the average composition of the mixture will fall below the levels considered suspect, and will be suitable for placement under the topsoil.

Drill Hole: N49000, E44000

The best overburden materials available to place under the topsoil are the 0 to 7 and 64 to 74 foot depths. It may be impractical to separate out the 64 to 74 foot depth. If eight feet of non-toxic material must be left on the surface, it would be more practical to mix the soil from 0 to 8 feet. This would not increase the conductivity above the slightly saline level; however, if the overburden above the Rosebud seam is thoroughly mixed during the stripping process, the average composition of the mixture will fall below the levels considered suspect, and will be suitable for placement under the topsoil.

Drill Hole: N49000, E46000

The surface soil (0 to 3 feet) is not recommended for replacement on the surface due to high salt and sodium concentrations. The best overburden materials available to place under the topsoil are the 3 to 14 and 17 to 57 foot depths. However, if the salt and sodium concentrations are in the third foot, rather than in the 0 to 2 foot depth, the top two feet could be used for retopsoiling. Soil survey test results should be studied to make this determination. As in the above drill holes, if the overburden above the Rosebud seam is thoroughly mixed during the stripping process, the average composition of the mixture will fall below the levels considered suspect, and will be suitable for placement under the topsoil.

Drill Hole: N49000, E48000

The best overburden material available to place under the topsoil is the 0 to 20 foot depth. However, if the overburden above the Rosebud seam is thoroughly mixed during the stripping process, the average composition of the mixture will fall below the levels considered suspect, and will be suitable for placement under the topsoil.

Drill Hole: N49000, E50000

We suggest that the 0 to 3 foot interval be resampled and tested every foot to determine the extent of the high zinc concentration. If it is located in the 2 to 3 foot interval, it could be removed with the 4 to 7 foot depth, which also contains a high concentration of zinc. This might allow the 0 to 2 foot depth to be used as retopsoiling material. The texture of the 8 to 12 foot depth is a silty clay, and 12 to 15 feet is a silty clay loam. These two intervals can be mixed and placed under the topsoil without adverse affects.

Drill Hole: N49000, E52000

The best overburden material to place under the topsoil is the interval from 0 to 16 feet. However, if the overburden above the Rosebud seam is thoroughly mixed during the stripping process, the average composition of the mixture will fall below the levels considered suspect, and will be suitable for placement under the topsoil.

Drill Hole: N50000, E52000

The only materials which appear suitable for placement beneath the topsoil are the 20 to 22 and 26 to 29 foot depths. Mixing these two depths would also require a dilution of the salt concentration in the 20 to 22 foot depth, and the zinc concentration and clay content in the 26 to 29 foot depth. To obtain the eight feet of non-toxic material on the surface, you may consider bringing material from N49000, E52000 to this site.

Drill Hole: N51000, E48000

The best overburden materials available to place under the topsoil are the intervals from 20 to 30 and 35 to 40 feet. However, the salt content of the 0 to 10 and 10 to 20 foot depths is the only problem preventing these materials from being replaced on the surface. Conductivities of 4.55 and 5.45 are in the low end of the medium salinity category, and would probably not be a great hindrance to revegetation if placed below the topsoil surface. Resampling the 0 to 10 foot depth by one foot increments and analyzing for conductivity would be advisable to try to isolate the location of the salt concentration. The best alternative would be to thorougnly mix the overburden above the Rosebud seam during the stripping process. The average composition of the mixture will fall below the levels considered suspect, and will be suitable for placement under the topsoil.

Drill Hole: N52000, E47000

The best overburden material available to place under the topsoil is the interval from 130 to 150 feet. However, the interval from 0 to 20 feet has conductivities in the lower to medium end of the medium salinity category, and may be a suitable alternative for placement under the topsoil. These depths must be mixed thoroughly. Selection of plants with moderate salt tolerance should be considered for revegetation of this area.

Drill Hole: N53000, E48000

The best overburden material available to place under the topsoil is the 0 to 17 foot depth. However, if the overburden from 0 to 85 feet is thoroughly mixed during the stripping process, the average composition of the mixture will fall below the levels considered suspect, and will be suitable for placement under the topsoil.

Drill Hole: N55000, E48000

Adequate material for placement under the topsoil may be obtained in the depths from 0 to 8 feet. If additional soil material is necessary, it may be taken from the 24 to 29 foot depths.

Drill Hole: N54000, E47000

The 0 to 2 foot depth at this site is free from suspect levels of salt and heavy metals, and should be used as topsoil. If the 2 to 6 and 6 to 8 foot depths were mixed and placed below the 0 to 2 foot depth, revegetation could probably be accomplished.

NORTHERN TESTING LABORATORIES, INC.
CONSULTING SOILS ENGINEERS
Great Falls, Billings, Montana - Boise, Idaho - Gillette, Wyoming

TABLE 1
WESTERN ENERGY COMPANY

Sheet 1 of 7
Job No. 69-147

Sample locations and depths of overburden and innerburden materials containing suspect levels of chemical and/or physical properties which could interfere with revegetation of coal strip mined and regraded areas.

Sample Location	Depth In Feet	Lab No.	Conductivity mmhos	SAR	Texture	Ammonium Nitrogen ppm	Zinc ppm	Cadmium ppm	Lead ppm	Nickel ppm
N47000	5 - 10	53953	4.2							
E44000	10 - 15	53954			Clay					
	15 - 20	53955			Silty Clay					1.49
	32 - 35	53958								2.76
	35 - 45	53959								2.48
	45 - 55	53960								2.01
	120 - 130	53968								1.21
	130 - 140	53969								1.01
	140 - 150	53970			Clay		46.9 Berry			1.80
	150 - 155	53971			Clay		33.2			1.61
IB	176 - 180	53972			Clay					2.31
	180 - 190	53973					127.0			1.62
	190 - 200	53974					47.1			1.20
	200 - 210	53975					441.0	0.19		
	220 - 230	53976					459.0	0.17		
	230 - 235	53977					300.0	0.15		
N47000	15 - 23	53924					✝ 111.0 Berry			
E46000	23 - 32	53925								2.30
IB	53 - 60	53926								1.42
	60 - 70	53927					459.0	0.19		
	80 - 90	53929					300.0	0.14		
	90 - 100	53930					153.0			
	100 - 110	53931					102.0			
	110 - 113	53932					75.8			

NORTHERN TESTING LABORATORIES, INC.
CONSULTING SOILS ENGINEERS
Great Falls, Billings, Montana - Boise, Idaho - Gillette, Wyoming

TABLE 1
WESTERN ENERGY COMPANY

Sheet 2 of 7
Job No. 69-147

Sample Location	Depth In Feet	Lab No.	Conductivity mmhos	SAR	Texture	Ammonium Nitrogen ppm	Zinc ppm	Cadmium ppm	Lead ppm	Nickel ppm
N49000	7 - 17	54066	7.36							
E44000	17 - 20	54067	5.42		Clay					
	20 - 30	54068			Clay					
	30 - 34	54069								1.26
	34 - 44	54070					29.9			1.55
	44 - 54	54071			Clay					1.39
	54 - 64	54072								1.36
	74 - 84	54074					49.7 Bury			
	95 - 100	54076								1.75
	100 - 109	54077								1.29
	109 - 118	54078			Silty Clay					1.03
	128 - 138	54080						0.11		1.35
1B	158 - 160	54081			Silty Clay					1.36
	170 - 180	54083					240.0	0.20		
	180 - 190	54084					678.0	0.35		
	190 - 200	54085					576.0	0.36		
	200 - 210	54086					642.0	0.35		
	210 - 220	54087					492.0	0.28		
N49000	0 - 3	53933	9.19	11.75	- retest					
E46000	14 - 17	53935						0.35		
	64 - 67	53941			Clay					1.92
	67 - 77	53942								2.51
	77 - 87	53943								2.47
	87 - 97	53944			Clay					1.51

NORTHERN TESTING LABORATORIES, INC.
CONSULTING SOILS ENGINEERS
Great Falls, Billings, Montana - Boise, Idaho - Gillette, Wyoming

TABLE 1
WESTERN ENERGY COMPANY

Sheet 3 of 7
Job No. 69-147

Sample Location	Depth in Feet	Lab No.	Conductivity mmhos	SAR	Texture	Ammonium Nitrogen ppm	Zinc ppm	Cadmium ppm	Lead ppm	Nickel ppm
1B	106 - 116	53945					93.0			1.00
	120 - 130	53946					522.0	0.20		
	130 - 140	53947					612.0	0.20		
	140 - 150	53948					585.0	0.19		
	150 - 160	53949					83.0			
	160 - 170	53950					342.0	0.22		
	170 - 176	53951					185.0	0.11		
N49000	8 - 11	54046			Silty Clay					
E48000	20 - 27	54050			Silty Clay					1.43
	38 - 40	54052			Silty Clay					1.62
	46 - 53	54054					34.2			
	56 - 66	54056					77.2 - Pang			1.75
1B	104 - 108	54058					129.0	0.12		
	116 - 126	54059					216.0	0.13		
	126 - 136	54060					53.9			
	136 - 146	54061					135.0			
	146 - 156	54062					42.3			
	156 - 165	54063					38.4			
N49000	0 - 3	53885					85.0 - contaminated samples			
E50000	3 - 8	53886	9.95 - [illegible]				154.0	0.11		
	8 - 12	53887			Silty Clay					
	15 - 20	53889			Clay					
	20 - 25	53890			Clay					

NORTHERN TESTING LABORATORIES, INC.
CONSULTING SOILS ENGINEERS
Great Falls, Billings, Montana - Boise, Idaho - Gillette, Wyoming

TABLE 1
WESTERN ENERGY COMPANY

Sheet 4 of 7
Job No. 69-147

Sample Location	Depth in Feet	Lab No.	Conductivity mmhos	SAR	Texture	Ammonium Nitrogen ppm	Zinc ppm	Cadmium ppm	Lead ppm	Nickel ppm
1B	55 - 60	53892					387.0	0.24		
	60 - 70	53893					241.0	0.14		
	70 - 80	53894					34.9			
	80 - 90	53895					156.0			
	90 - 97	53896					152.0			1.00
	97 - 100	53897					199.0	0.11		1.25
N49000 E52000	26 - 36	53907					84.5	Query		1.17
1B	58 - 68	53909			Clay		139.0	0.10		1.43
	68 - 75	53909					138.0			1.11
	75 - 80	53910					94.0			
	80 - 85	53911					350.0	0.19		1.32
N50000 E52000	0 - 10	53912					173.0 – probably contamination			
	10 - 16	53913	8.40	9.35						
	16 - 20	53914	10.2	11.39						
	20 - 22	53915	5.75							
	22 - 26	53916					378.0	0.22		
	26 - 29	53917			Clay		53.2	Query		
1B	51 - 61	53918					48.9			1.15
	61 - 71	53919								1.01
	71 - 76	53920					47.6			1.89

NORTHERN TESTING LABORATORIES, INC.
CONSULTING SOILS ENGINEERS
Great Falls, Billings, Montana - Boise, Idaho - Gillette, Wyoming

TABLE 1
WESTERN ENERGY COMPANY

Sheet 5 of 7
Job No. 69-147

Sample Location	Depth in Feet	Lab No.	Conductivity mmhos	SAR	Texture	Ammonium Nitrogen ppm.	Zinc ppm	Cadmium ppm	Lead ppm	Nickel ppm
N51000	0 - 10	52529	5.45							
E48000	10 - 20	52530	4.55							
	30 - 35	52532			Silty Clay					
	40 - 45	52534								1.66
	80 - 90	52539								1.38
	90 - 100	52540								1.35
IB	160 - 170	52543								1.33
N52000	0 - 5	52510	6.20							
E47000	5 - 10	52511	8.50							
	10 - 15	52512	5.30							
	15 - 20	52513	6.50		Clay					
	20 - 30	52514		15.34	Silty Clay					1.29
	30 - 35	52515		24.13	Silty Clay	29.4				1.85
	35 - 40	52516		28.85		31.9				2.04
	40 - 50	52517		29.37		32.6				1.87
	50 - 60	52518		27.72		37.8				1.68
	60 - 63	52519	4.95	23.99	Clay	25.4				2.62
	63 - 70	52520		29.59	Silty Clay	32.2				
	70 - 80	52521		31.27						
	80 - 90	52522	5.10	49.86	Silty Clay					
	90 - 100	52523		16.65						1.34
	100 - 110	52524		15.76	Silty Clay	26.9				
	110 - 120	52525		16.49						
	120 - 130	52526		13.83						
IB	185 - 195	52956								1.06
	205 - 215	52958								2.92
	225 - 235	52960								1.25

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NORTHERN TESTING LABORATORIES, INC.
CONSULTING SOILS ENGINEERS
Great Falls, Billings, Montana - Boise, Idaho - Gillette, Wyoming

TABLE 1
WESTERN ENERGY COMPANY

Sheet 6 of 7
Job No. 69-147

Sample Location	Depth in Feet	Lab No.	Conductivity mmhos	SAR	Texture	Ammonium Nitrogen ppm	Zinc ppm	Cadmium ppm	Lead ppm	Nickel ppm
N53000	0 - 5	52885	5.50							
E48000	5 - 10	52886	5.10							
	17 - 19	52889			Silty Clay					
	19 - 21	52890			Silty Clay					
	26 - 28	52892			Clay				18.6	1.88
	32 - 35	52894				67.5				
	35 - 45	52895			Silty Clay					2.15
	45 - 55	52896								1.65
	55 - 65	52897								1.28
	65 - 75	52898								1.41
	75 - 85	52899								1.57
	85 - 92	52900	4.50		Clay	31.5				5.65 [illegible]
1B	117 - 127	52901								1.58
	157 - 162	52905								1.37
N55000	8 - 13	52907	8.75	12.23						
E48000	13 - 17	52908	8.00	11.72						
	17 - 24	52909	5.30	11.07						
	24 - 29	52910	4.30							1.00
	29 - 32	52911		12.87						
	32 - 35	52912		10.17	Clay					1.17
	35 - 42	52913		11.25						
	42 - 45	52914		10.54						
	45 - 47	52915		10.77						
	47 - 51	52916		11.89	Clay					1.75
	51 - 55	52917		17.62						
	55 - 57	52918	4.60		Silty Clay					1.80
	57 - 64	52919		25.11						
	64 - 74	52920		23.14						1.41

NORTHERN TESTING LABORATORIES, INC.
CONSULTING SOILS ENGINEERS
Great Falls, Billings, Montana - Boise, Idaho - Gillette, Wyoming

TABLE 1
WESTERN ENERGY COMPANY

Sheet 7 of 7
Job No. 69-147

Sample Location	Depth in Feet	Lab No.	Conductivity mmhos	SAR	Texture	Ammonium Nitrogen ppm	Zinc ppm	Cadmium ppm	Lead ppm	Nickel ppm
1B	105 - 110	52912		17.38	Silty Clay					
	110 - 120	52922		11.13						1.24
	120 - 130	52923		12.77						
N54000	2 - 6	52928	7.10		Clay					
E47000	6 - 8	52929	7.00							
	8 - 11	52930	6.40		Silty Clay					
	11 - 14	52931	6.25							
	14 - 17	52932	6.50							
	17 - 19	52933	5.95							
	19 - 21	52934	4.50	10.05						
	21 - 27	52935	4.60	12.34						
	27 - 31	52936	6.50	12.27	Silty Clay					
	31 - 36	52937		23.89	Silty Clay	32.9				1.62
	36 - 46	52938		25.23	Silty Clay	38.3				2.47
	46 - 56	52939		29.93	Silty Clay	44.4				2.76
	56 - 66	52940		36.14		30.1				1.60
	66 - 76	52941	6.80	20.58	Clay	26.9				2.44
	76 - 86	52942		20.58						1.10
	86 - 96	52943		35.33	Silty Clay				15.5	
	96 - 106	52944		31.29		25.4				1.11
	106 - 116	52945		29.24	Silty Clay					0.98
	116 - 126	52946		25.89		26.9				1.04
	126 - 136	52947		18.45		25.1				1.47
	136 - 146	52948		20.24						1.13
	146 - 156	52949		18.33	Silty Clay					2.52
	156 - 159	52950	5.40	14.33		31.5		0.23		2.03
1B	183 - 190	52951								1.10

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NORTHERN TESTING LABORATORIES, INC.
CONSULTING SOILS ENGINEERS
Great Falls, Billings, Montana - Boise, Idaho - Gillette, Wyoming

TABLE 2
WESTERN ENERGY COMPANY

Sheet 1 of 2
Job No. 69-147

Sample locations and depths of overburden soil materials which appear to be most suitable for revegetation of coal strip mined and regraded areas.

Sample Location	Depth in Feet	Lab No.	Conductivity mmhos	SAR	Texture	Ammonium Nitrogen ppm	Zinc ppm	Cadmium ppm	Lead ppm	Nickel ppm
N47000	0 - 5	53952	3.68	2.11	Silt Loam	5.3	4.61	-0.01*	0.8	0.35
E44000	20 - 29	53956	2.02	1.90	Loam	14.8	3.83	0.02	1.2	0.83
	29 - 32	53957	1.99	1.95	Loam	8.4	2.35	0.01	0.6	0.79
N47000	0 - 2	53921	0.50	0.14	Loam	5.9	9.85	0.02	0.9	0.06
E46000	2 - 5	53922	0.23	0.09	Loam	7.0	0.49	-0.01	0.7	0.09
	5 - 15	53923	0.32	0.29	Sandy Loam	5.0	0.63	-0.01	0.6	0.08
N49000	0 - 3	54064	0.38	0.24	Sandy Loam	3.6	5.85	0.03	0.7	0.18
E44000	3 - 7	54065	3.71	5.98	Sandy Clay Loam	3.4	1.43	0.03	0.6	0.17
	64 - 74	54073	1.38	4.06	Sandy Loam	4.5	1.79	0.04	1.1	0.35
N49000	3 - 14	53934	2.99	6.60	Sandy Loam	7.0	1.53	0.01	0.3	0.18
E46000	17 - 21	53936	2.29	5.82	Sandy Loam	4.5	15.9	0.01	0.3	0.24
	21 - 31	53937	2.28	5.04	Sandy Loam	6.7	2.56	0.01	0.5	0.26
	31 - 47	53938	2.67	4.42	Sandy Loam	5.0	6.82	-0.01	0.6	0.29
	47 - 57	53939	2.16	3.91	Loamy Sand	14.8	3.89	0.01	0.6	0.31
N49000	0 - 1	54043	0.59	0 24	Sandy Loam	10.1	22.4	0.05	0.8	0.37
E48000	1 - 4	54044	0.51	0.85	Clay Loam	4.2	9.37	0.02	0.6	0.15
	4 - 8	54045	1.01	1.60	Silty Clay Loam	5.6	14.3	0.02	1.4	0.12
	11 - 16	54047	0.74	0.77	Silty Clay Loam	6.2	2.94	0.04	1.2	0.12
	16 - 18	54048	0.73	0.63	Silty Clay Loam	10.9	1.70	0.01	3.4	0.47
	18 - 20	54049	0.77	0.58	Silt Loam	16.0	0.79	0.04	0.8	0.12

5 – 10 – 6 ft.

7 – 12 [illegible]

[illegible] for Cond + [illegible]

*Minus sign indicates concentration is less than value shown.

NORTHERN TESTING LABORATORIES, INC.
CONSULTING SOILS ENGINEERS
Great Falls, Billings, Montana - Boise, Idaho - Gillette, Wyoming

TABLE 2
WESTERN ENERGY COMPANY

Sheet 2 of 2
Job No. 69-147

Sample Location	Depth in Feet	Lab No.	Conductivity mmhos	SAR	Texture	Ammonium Nitrogen ppm	Zinc ppm	Cadmium ppm	Lead ppm	Nickel ppm
N49000 E50000	0 - 3	53885	0.35	0.25	Loam	10.9	85.0	0.07	0.7	0.30
	12 - 15	53888	2.06	0.45	Silty Clay Loam	7.3	1.64	0.02	1.1	0.25
N49000 E52000	0 - 2	53898	0.38	0.34	Sandy Loam	6.4	2.31	-0.01	0.4	0.09
	2 - 5	53899	0.91	3.51	Loam	7.6	1.32	-0.01	0.4	0.07
	5 - 9	53900	3.10	3.12	Silt Loam	8.1	4.14	-0.01	0.5	0.04
	9 - 12	53901	3.60	1.39	Sandy Loam	7.0	0.59	-0.01	0.7	0.05
	12 - 16	93302	0.45	0.77	Silty Clay Loam	6.7	1.48	-0.01	1.1	0.03
N50000 E52000	20 - 22	53915	5.75	5.08	Sandy Loam	6.2	2.26	-0.01	0.5	0.05
	26 - 29	53917	1.70	0.91	Clay	12.6	53.2	0.04	2.0	-0.01
N51000 E48000	20 - 30	52531	3.15	2.10	Clay Loam	16.1	14.4	-0.01	1.20	0.16
	35 - 40	52533	2.80	1.35	Clay Loam	19.7	5.72	0.01	2.96	0.98
N52000 E47000	0 - 5	52510	6.20	5.25	Silty Loam	22.9	10.2	0.03	1.3	0.19
	10 - 15	52512	5.30	8.89	Silt Loam	15.4	2.92	-0.01	0.9	0.03
	130 - 140	52527	1.95	8.86	Sandy Loam	15.0	2.39	-0.01	0.7	0.89
	140 - 150	52528	1.55	6.84	Loamy Sand	16.5	3.27	-0.01	1.1	0.84
N53000 E48000	0 - 5	52885	5.50	4.18	Silt Loam	13.2	1.86	0.02	0.7	-0.01
	5 - 10	52886	5.10	4.90	Silty Clay Loam	14.7	1.92	0.03	1.4	-0.01
	10 - 15	52887	3.70	4.24	Clay Loam	15.4	0.90	0.01	2.3	0.09
	15 - 17	52888	3.50	4.97	Silty Clay Loam	19.0	1.74	0.01	2.1	0.04
N55000 E48000	0 - 8	52906	0.65	6.28	Sandy Clay Loam	18.6	2.58	0.04	1.3	0.33
	24 - 29	52910	4.30	8.55	Silty Clay Loam	20.8	1.93	0.05	6.0	1.00
N54000 E47000	0 - 2	52927	2.35	0.14	Silt Loam	24.7	8.35	0.03	0.6	0.14
	2 - 6	52928	7.10	5.95	Clay	15.8	1.52	0.07	3.1	0.67
	6 - 8	52929	7.00	6.91	Silt Loam	23.6	3.15	0.03	1.6	0.04

NORTHERN TESTING LABORATORIES, INC.
CONSULTING GEOTECHNICAL ENGINEERS
Great Falls Billings, Montana - Boise, Idaho - Gillette, Wyoming

REVISED: March 23, 1976
February 17, 1976
Job No. 69-147

CHEMICAL ANALYSIS OF TOPSOIL AND OVERBURDEN
AREA A, SECTION 5
N47000-E44000
WESTERN ENERGY COMPANY - COLSTRIP, MONTANA

Depth, Feet	Lab No.	pH	Conductivity mmhos/cm	Saturation %	Calcium meq/Liter	Calcium meq/100 grams*	Magnesium meq/Liter	Magnesium meq/100 grams*	Sodium meq/Liter	Sodium meq/100 grams*	SAR	Texture**	Probable Subsurface Formation
0 - 5	53952	8.0	3.68	43.7	11.8	0.52	34.2	1.51	10.1	0.44	2.11	Silt Loam	Brown Topsoil
5 - 10	53953	7.7	4.20	54.0	24.1	1.30	35.9	1.94	7.70	0.42	1.41	Silt Loam	Brown Topsoil
10 - 15	53954	7.7	3.90	72.6	23.8	1.74	32.2	2.35	7.01	0.51	1.33	Clay	Brown Clay
15 - 20	53955	7.8	3.01	65.2	15.1	0.98	21.2	1.38	6.26	0.41	1.47	Silty Clay	Brown Clay
20 - 25	53956	7.8	2.02	49.8	7.46	0.37	11.9	0.60	5.90	0.30	1.90	Loam	Brown Sandy Shale
25 - 32	53957	7.7	1.99	44.5	8.12	0.37	11.0	0.50	6.03	0.27	1.95	Loam	Brown Sandy Shale
32 - 35	53958	7.9	1.58	67.6	5.82	0.40	7.89	0.54	5.06	0.34	1.93	Silty Clay Loam	Gray Shale
35 - 45	53959	7.9	1.74	53.3	6.40	0.34	9.34	0.50	5.49	0.29	1.96	Loam	Gray Shale
45 - 55	53960	7.9	2.00	48.4	6.70	0.32	13.1	0.63	5.55	0.27	1.76	Loam	Gray Sandy Shale
55 - 60	53961	7.9	1.55	44.2	4.72	0.21	9.86	0.43	4.82	0.21	1.79	Loam	Brown Sandy Shale
60 - 70	53962	8.0	0.74	27.2	2.74	0.07	4.15	0.11	1.90	0.05	1.02	Sandy Loam	Brown Sandstone
70 - 80	53963	8.0	1.17	28.6	3.84	0.11	6.99	0.20	3.08	0.09	1.32	Loamy Sand	Brown Sandstone
80 - 90	53964	8.0	2.18	25.0	14.6	0.37	15.8	0.40	1.70	0.04	0.44	Loamy Sand	Brown Sandstone
90 - 100	53965	7.7	3.60	26.0	28.1	0.73	25.2	0.66	2.18	0.06	0.42	Sandy Loam	Brown Sandstone
100 - 110	53966	8.0	0.96	27.7	3.05	0.09	6.83	0.19	1.63	0.05	0.73	Loamy Sand	Brown Sandstone
110 - 120	53967	7.6	1.18	25.2	3.88	0.10	7.39	0.19	2.05	0.05	0.86	Sandy Loam	Brown Sandstone
120 - 130	53968	7.8	2.20	24.2	12.4	0.30	14.8	0.36	2.80	0.07	0.76	Loamy Sand	Gray Sandstone
130 - 140	53969	7.6	1.70	24.8	8.78	0.22	10.0	0.25	3.35	0.08	1.09	Sandy Loam	Gray Sandstone
140 - 150	53970	7.8	1.50	52.3	7.24	0.38	8.57	0.45	2.68	0.14	0.95	Clay	Gray Shale
150 - 155	53971	7.3	1.20	54.0	4.15	0.22	7.18	0.39	2.78	0.15	1.17	Clay	Dark Gray Shale
175 - 180 I.B.	53972	6.9	2.40	53.4	9.00	0.48	15.1	0.80	3.50	0.19	1.01	Clay	Dark Gray Clay
180 - 190 I.B.	53973	7.2	2.21	41.5	7.83	0.33	14.2	0.60	3.49	0.15	1.05	Clay Loam	Dk. Gray Sandy Shale
190 - 200 I.B.	53974	7.6	1.37	30.3	5.61	0.17	10.7	0.32	4.48	0.13	1.57	Sandy Loam	Dark Gray Sandstone
200 - 210 I.B.	53975	7.9	3.01	23.1	11.6	0.27	16.0	0.37	7.18	0.17	1.93	Sandy Loam	Gray Sandstone
220 - 230 I.B.	53976	8.0	1.94	21.0	9.14	0.19	9.14	0.19	4.52	0.10	1.50	Sandy Loam	Gray Sandstone
230 - 235 I.B.	53977	7.9	1.13	22.4	4.45	0.10	5.09	0.11	2.45	0.05	1.12	Loamy Sand	Gray Sandstone

*Oven Dry Soil **U. S. Department of Agriculture Soil Textural Triangle

NORTHERN TESTING LABORATORIES, INC.
CONSULTING GEOTECHNICAL ENGINEERS
Great Falls, Billings, Montana - Boise, Idaho - Gillette, Wyoming

ANALYSIS OF TRACE ELEMENTS IN OVERBURDEN
AREA A, SECTION 5
WESTERN ENERGY COMPANY - COLSTRIP, MONTANA

February 17, 1976
Job No. 69-147

All in Parts Per Million (-) Indicates Less Than Given Value

Sample Location	Depth. Ft.	Lab No.	Nitrate Nitrogen	Ammonia Nitrogen	Boron	Selenium	Molybdenum	Mercury	Zinc	Iron	Manganese	Copper	Cadmium	Lead	Nickel
N47000- E44000	0 - 5	53952	-0.01	5.3	0.37	-0.02	0.26	0.053	4.61	12.5	3.80	0.58	-0.01	0.8	0.35
	5 - 10	53953	-0.01	13.4	0.41	-0.02	0.30	0.063	1.72	20.5	4.28	1.04	0.02	1.6	0.48
	10 - 15	53954	-0.01	19.9	0.45	-0.02	0.20	0.118	1.65	36.0	7.90	2.54	0.05	1.7	0.77
	15 - 20	53955	-0.01	20.7	0.26	-0.02	0.28	0.130	4.01	57.9	11.9	3.38	0.04	2.2	1.49
	20 - 29	53956	-0.01	14.8	0.04	-0.02	0.45	0.074	3.83	23.6	5.56	0.95	0.02	1.2	0.83
	29 - 32	53957	-0.01	8.4	0.33	-0.02	0.39	0.084	2.35	16.9	3.23	0.64	0.01	0.6	0.79
	32 - 35	53958	-0.01	21.8	0.45	-0.02	0.37	0.112	5.08	72.9	10.6	3.51	0.03	3.8	2.76
	35 - 45	53959	-0.01	17.6	0.42	-0.02	0.54	0.049	10.2	60.1	3.83	1.85	0.02	3.1	2.43
	45 - 55	53960	-0.01	10.6	0.37	-0.02	0.50	0.101	4.77	49.9	5.03	1.33	0.02	2.5	2.01
	55 - 60	53961	-0.01	7.3	0.33	-0.02	0.39	0.071	1.35	12.6	2.38	0.62	-0.01	0.7	0.53
	60 - 70	53962	-0.01	4.8	1.15	-0.02	0.20	0.045	0.89	6.7	1.90	0.21	-0.01	0.2	0.30
	70 - 80	53963	-0.01	7.0	0.30	-0.02	-0.20	0.055	0.90	7.2	1.41	0.20	-0.01	0.2	0.27
	80 - 90	53964	0.17	5.0	0.22	-0.02	-0.20	0.036	3.19	10.5	1.39	0.21	-0.01	0.5	0.26
	90 - 100	53965	0.83	6.7	0.37	-0.02	0.34	0.055	3.80	12.2	1.25	0.36	-0.01	0.4	0.40
	100 - 110	53966	-0.01	3.6	0.30	-0.02	0.30	0.039	3.21	9.1	1.65	0.35	-0.01	0.5	0.29
	110 - 120	53967	0.22	3.6	0.41	-0.02	0.32	0.063	3.68	18.8	2.14	0.75	-0.01	0.6	0.45
	120 - 130	53968	-0.01	5.3	0.48	-0.02	0.40	0.099	6.75	30.2	2.22	0.68	-0.01	0.8	1.21
	130 - 140	53969	-0.01	6.2	0.19	-0.02	0.48	0.059	4.16	51.3	2.54	0.44	-0.01	1.2	1.01
	140 - 150	53970	-0.01	10.9	0.60	-0.02	0.30	0.175	46.9	47.7	0.99	6.65	0.04	3.7	1.80
	150 - 155	53971	-0.01	10.6	1.64	-0.02	0.34	0.192	33.2	81.5	2.20	3.40	0.06	6.2	1.61
1.B.	175 - 180	53972	-0.01	16.2	2.94	-0.02	0.36	0.318	21.0	55.6	3.09	4.42	0.06	7.8	2.31
1.B.	180 - 190	53973	-0.01	11.8	2.57	-0.02	0.28	0.383	127.0	73.0	4.48	2.65	0.09	3.5	1.62
1.B.	190 - 200	53974	-0.01	4.2	1.34	-0.02	0.46	0.293	47.1	55.8	3.31	0.93	0.03	2.1	1.20
1.B.	200 - 210	53975	-0.01	6.7	1.03	-0.02	0.30	0.148	441.0	4.9	1.52	0.19	0.19	0.1	0.74
1.B.	220 - 230	53976	-0.01	5.9	1.04	-0.02	-0.20	0.089	459.0	6.4	1.78	0.16	0.17	0.1	0.73
1.B.	230 - 235	53977	-0.01	4.5	0.56	-0.02	-0.20	0.105	300.0	25.1	3.75	0.41	0.15	1.0	0.69

NORTHERN TESTING LABORATORIES, INC.
CONSULTING GEOTECHNICAL ENGINEERS
Great Falls, Billings, Montana - Boise, Idaho - Gillette, Wyoming

February 17, 1976
Job No. 69-147

CHEMICAL ANALYSIS OF TOPSOIL AND OVERBURDEN
AREA A, SECTION 5
N47000-E46000
WESTERN ENERGY COMPANY - COLSTRIP, MONTANA

Depth, Feet	Lab No.	pH	Conduct-tivity mmhos/cm	Saturation %	Calcium meq/Liter	Calcium meq/100 grams*	Magnesium meq/Liter	Magnesium meq/100 grams*	Sodium meq/liter	Sodium meq/100 grams*	SAR	Texture**	Probable Subsurface Formation
0 - 2	53921	7.7	0.50	33.5	5.00	0.17	1.75	0.06	0.26	0.01	0.14	Loam	Brown Topsoil
2 - 5	53922	7.9	0.23	31.5	1.94	0.06	1.30	0.04	0.12	-0.01	0.09	Loam	Brown Topsoil
5 - 15	53923	8.1	0.32	27.9	1.11	0.03	2.78	0.08	0.40	0.01	0.29	Sandy Loam	Brown Sandstone
15 - 23	53924	7.7	0.72	60.1	1.20	0.07	3.70	0.22	2.82	0.17	1.80	Silty Clay Loam	Brown Shale
23 - 32	53925	5.0	1.45	56.1	5.15	0.29	6.48	0.36	5.96	0.33	2.47	Clay Loam	Gray Sandy Shale
53 - 60 I.B.	53926	6.9	2.94	46.1	16.8	0.77	18.2	0.84	6.80	0.31	1.63	Clay Loam	Gray Shale
60 - 70 I.B.	53927	7.2	2.46	33.6	12.7	0.43	14.1	0.47	5.72	0.19	1.56	Sandy Loam	Gray Sandstone
70 - 80 I.B.	53928	7.1	1.75	27.9	8.01	0.22	8.22	0.23	4.32	0.12	1.52	Sand	Gray Sandstone
80 - 90 I.B.	53929	7.3	2.50	28.3	9.90	0.28	12.8	0.36	5.94	0.17	1.76	Loamy Sand	Gray Sandstone
90 - 100 I.B.	53930	7.3	1.72	27.7	6.48	0.18	8.09	0.22	4.30	0.12	1.59	Sand	Gray Sandstone
100 - 110 I.B.	53931	7.8	1.30	28.2	7.35	0.21	6.23	0.18	2.85	0.08	1.09	Loamy Sand	Gray Sandstone
110 - 113 I.B.	53932	8.3	1.30	29.0	7.69	0.22	5.99	0.17	3.17	0.09	1.21	Sand	Gray Sandstone

*Oven Dry Soil
**U. S. Department of Agriculture Soil Textural Triangle

NORTHERN TESTING LABORATORIES, INC.
CONSULTING GEOTECHNICAL ENGINEERS
Great Falls, Billings, Montana - Boise, Idaho - Gillette, Wyoming

ANALYSIS OF TRACE ELEMENTS IN OVERBURDEN
AREA A, SECTION 5
WESTERN ENERGY COMPANY - COLSTRIP, MONTANA

February 17, 1976
Job No. 69-147

All In Parts Per Million .(-) Indicates Less Than Given Value

Sample Location	Depth, Ft.	Lab No.	Nitrate Nitrogen	Ammonia Nitrogen	Boron	Selenium	Molybdenum	Mercury	Zinc	Iron	Manganese	Copper	Cadmium	Lead	Nickel
N47000-E46000	0 - 2	53921	2.94	5.9	1.12	0.02	0.35	0.040	9.85	7.6	6.59	1.55	0.02	0.9	0.06
	2 - 5	53922	-0.01	7.0	0.37	-0.02	0.31	0.034	0.49	3.8	2.44	0.66	-0.01	0.7	0.09
	5 - 15	53923	-0.01	5.0	0.37	-0.02	0.27	0.040	0.63	13.8	4.03	0.46	-0.01	0.6	0.08
	15 - 23	53924	-0.01	6.2	0.71	-0.02	0.20	0.095	111.0	26.1	13.7	1.68	0.07	1.1	0.37
	23 - 32	53925	-0.01	12.9	2.16	-0.02	2.55	0.370	5.63	174.0	0.99	0.99	0.02	0.1	2.30
I.B.	53 - 60	53926	-0.01	5.3	1.38	-0.02	0.24	0.155	16.7	25.8	5.02	2.55	0.01	3.8	1.42
I.B.	60 - 70	53927	-0.01	5.6	4.24	-0.02	0.22	0.034	459.0	1.6	1.95	0.12	0.19	0.3	0.85
I.B.	70 - 80	53928	-0.01	5.0	2.42	-0.02	0.21	0.039	25.1	15.3	4.65	0.73	0.03	1.2	0.73
I.B.	80 - 90	53929	-0.01	3.9	1.97	-0.02	-0.20	0.036	300.0	14.4	5.74	0.49	0.14	1.1	0.49
I.B.	90 - 100	53930	-0.01	4.2	1.38	-0.02	-0.20	0.049	153.0	17.9	4.48	0.50	0.03	1.2	0.68
I.B.	100 - 110	53931	-0.01	14.0	0.97	-0.02	0.20	0.045	102.0	19.8	3.75	0.39	0.03	1.3	0.65
I.B.	110 - 113	53932	-0.01	5.0	1.38	-0.02	0.21	0.049	75.8	14.9	4.90	0.35	0.01	1.0	0.63

NORTHERN TESTING LABORATORIES, INC.
CONSULTING GEOTECHNICAL ENGINEERS
Great Falls, Billings, Montana - Boise, Idaho - Gillette, Wyoming

CHEMICAL ANALYSIS OF TOPSOIL AND OVERBURDEN
AREA A, SECTION 5
WESTERN ENERGY COMPANY - COLSTRIP, MONTANA
N49000 - E44000

February 24, 1976
Job No. 69-147

Depth, Feet	Lab No.	pH	Conductivity mmhos/cm	Saturation %	Calcium, meq/Liter	Calcium meq/100 grams*	Magnesium meq/Liter	Magnesium meq/100 grams*	Sodium meq/Liter	Sodium meq/100 grams*	SAR	Texture**	Probable Subsurface Formation
0 - 3	54064	8.0	0.38	28.2	1.85	0.05	2.99	0.08	0.37	0.01	0.24	Sandy Loam	Brown Topsoil
3 - 7	54065	8.2	3.71	31.6	4.20	0.13	23.9	0.76	22.4	0.71	5.98	Sandy Clay Loam	Brown Topsoil
7 - 17	54066	8.1	7.36	38.0	22.4	0.85	62.0	2.36	38.4	1.40	5.91	Loam	Brown Sandy Topsoil
17 - 20	54067	7.9	5.42	66.2	19.1	1.26	41.5	2.75	25.1	1.66	4.56	Clay	Brown Clay
20 - 30	54068	7.4	1.17	68.7	4.17	0.29	5.85	0.40	4.65	0.32	2.08	Clay	Gray Shale
30 - 34	54069	7.4	2.31	46.5	10.3	0.48	13.1	0.61	7.55	0.35	2.21	Silt Loam	Gray Shale
34 - 44	54070	7.7	1.71	52.4	5.44	0.29	8.10	0.42	7.45	0.39	2.86	Silty Clay Loam	Gray Shale
44 - 54	54071	7.7	1.56	59.0	4.31	0.25	5.62	0.33	8.15	0.48	3.66	Clay	Gray Shale
54 - 64	54072	7.8	2.05	41.6	5.21	0.22	7.48	0.31	12.1	0.50	4.80	Silty Clay Loam	Gray Shale
64 - 74	54073	8.0	1.38	29.4	3.61	0.11	4.95	0.15	8.40	0.25	4.06	Sandy Loam	Brown Sandstone
74 - 84	54074	8.0	1.99	28.3	5.36	0.15	8.80	0.25	10.7	0.30	4.02	Sandy Loam	Brown Sandstone
84 - 95	54075	8.0	1.63	29.0	4.28	0.12	7.22	0.21	8.42	0.24	3.51	Sandy Loam	Gray Sandstone
95 - 100	54076	7.8	1.58	38.4	4.20	0.16	6.95	0.27	7.85	0.30	3.32	Clay Loam	Gray Sandy Shale
100 - 109	54077	7.7	2.07	36.7	7.45	0.27	9.56	0.35	8.88	0.33	3.05	Clay Loam	Gray Shale
109 - 118	54078	7.9	0.99	61.1	2.78	0.17	3.25	0.20	5.80	0.35	3.34	Silty Clay	Gray Shale
118 - 128	54079	8.0	1.01	55.7	2.66	0.15	2.86	0.16	6.05	0.34	3.64	Clay Loam	Gray Shale
128 - 138	54080	7.3	1.25	41.8	3.89	0.16	4.67	0.20	6.65	0.28	3.21	Clay Loam	Gray Sandy Shale
158 - 160 I.B.	54081	7.1	1.52	49.2	6.58	0.32	6.81	0.34	5.50	0.27	2.13	Silty Clay	Gray Shale
160 - 170 I.B.	54082	7.6	1.55	44.7	6.32	0.28	7.08	0.32	5.20	0.23	2.01	Silty Clay Loam	Gray Shale
170 - 180 I.B.	54083	7.7	1.90	49.5	7.36	0.36	8.84	0.44	6.35	0.31	2.23	Silty Clay Loam	Gray Shale
180 - 190 I.B.	54084	7.9	1.98	27.2	9.31	0.25	7.98	0.22	7.25	0.20	2.47	Loamy Sand	Gray Sandstone
190 - 200 I.B.	54085	7.7	1.95	28.7	8.46	0.24	8.49	0.24	7.55	0.22	2.59	Sandy Loam	Gray Sandstone
200 - 210 I.B.	54086	7.7	2.24	25.0	10.1	0.25	9.11	0.23	9.40	0.24	3.03	Sandy Loam	Gray Sandstone
210 - 220 I.B.	54087	7.7	1.97	29.4	9.78	0.29	9.78	0.29	4.90	0.14	1.57	Loamy Sand	Gray Sandstone

*Oven Dry Soil
**U. S. Department of Agriculture Soil Textural Triangle

NORTHERN TESTING LABORATORIES, INC.
CONSULTING GEOTECHNICAL ENGINEERS
Great Falls, Billings, Montana - Boise, Idaho - Gillette, Wyoming

ANALYSIS OF TRACE ELEMENTS IN OVERBURDEN
AREA A, SECTION 5
WESTERN ENERGY COMPANY - COLSTRIP, MONTANA

February 24, 1976
Job No. 69-147

All in Parts Per Million (-) Indicates Less Than Given Value

mple cation	Depth, Ft.	Lab No.	Nitrate Nitrogen	Ammonia Nitrogen	Boron	Selenium	Molybdenum	Mercury	Zinc	Iron	Manganese	Copper	Cadmium	Lead	Nickel
3000 -	0 - 3	54064	0.19	3.6	0.78	-0.02	-0.20	0.014	5.85	5.5	2.97	0.52	0.03	0.7	0.18
4000	3 - 7	54065	-0.01	3.4	0.82	-0.02	-0.20	0.017	1.43	7.9	1.99	0.73	0.03	0.6	0.17
	7 - 17	54066	-0.01	4.2	0.62	-0.02	-0.20	0.019	2.12	7.9	1.87	0.70	0.04	0.9	0.21
	17 - 20	54067	0.08	6.2	1.01	-0.02	-0.20	0.068	10.4	16.5	3.74	1.01	0.06	1.3	0.25
	20 - 30	54068	0.12	9.8	1.11	-0.02	0.24	0.059	7.65	20.4	4.55	5.98	0.07	6.5	0.84
	30 - 34	54069	0.12	9.2	0.88	-0.02	0.36	0.082	17.7	120.0	5.41	1.82	0.05	3.0	1.26
	34 - 44	54070	0.16	7.8	0.65	-0.02	0.32	0.040	29.9	77.9	10.4	3.03	0.07	4.4	1.55
	44 - 54	54071	0.12	8.1	0.43	-0.02	1.23	0.063	10.2	85.2	10.9	3.35	0.04	3.7	1.33
	54 - 64	54072	0.08	5.3	0.46	-0.02	0.58	0.051	11.0	62.8	5.62	1.89	0.05	3.5	1.36
	64 - 74	54073	0.16	4.5	0.72	-0.02	0.32	0.017	1.79	18.2	1.97	0.53	0.04	1.1	0.35
	74 - 84	54074	0.04	5.6	0.33	-0.02	0.27	0.034	49.7	18.3	2.49	0.78	0.06	1.2	0.20
	84 - 95	54075	0.04	2.5	0.10	-0.02	0.21	0.019	26.3	21.3	1.38	0.32	0.05	1.5	0.49
	95 - 100	54076	0.19	5.6	0.59	-0.02	0.43	0.047	5.49	60.4	5.69	2.29	0.05	4.6	1.75
	100 - 109	54077	0.04	7.3	0.56	-0.02	0.45	0.046	5.05	51.3	6.39	1.96	0.05	3.4	1.29
	109 - 118	54078	0.12	11.8	0.69	-0.02	-0.20	0.120	5.65	33.8	2.02	4.43	0.07	5.6	1.03
[illegible] -	118 - 128	54079	0.04	10.5	0.69	-0.02	-0.20	0.136	11.2	25.5	1.15	4.39	0.07	4.7	0.55
coal	128 - 138	54080	0.12	7.3	1.21	-0.02	-0.20	0.045	6.83	17.3	1.20	1.21	0.11	5.2	1.35
I.B.	155 - 160	54081	0.23	8.1	2.94	-0.02	0.32	0.080	8.42	31.3	5.27	2.39	0.09	7.2	1.36
I.B.	160 - 170	54082	0.12	5.3	0.78	-0.02	0.61	0.061	17.3	62.0	8.67	2.48	0.08	4.3	0.56
I.B.	170 - 180	54083	0.12	5.9	0.92	-0.02	0.42	0.057	240.0	51.2	7.41	2.37	0.20	5.6	0.55
I.B.	180 - 190	54084	0.04	2.2	0.65	-0.02	0.31	0.032	678.0	8.4	4.02	0.22	0.35	0.3	0.63
I.B.	190 - 200	54085	0.23	3.6	0.92	-0.02	0.24	0.030	576.0	16.2	6.90	0.58	0.36	2.1	0.70
I.B.	200 - 210	54086	0.04	3.1	0.52	-0.02	0.20	0.019	642.0	10.8	5.25	0.28	0.35	0.5	0.69
I.B.	210 - 220	54087	-0.01	2.5	0.52	-0.02	-0.20	0.017	492.0	22.2	3.85	0.41	0.28	1.8	0.53

NORTHERN TESTING LABORATORIES, INC.
CONSULTING GEOTECHNICAL ENGINEERS
Great Falls, Billings, Montana - Boise, Idaho - Gillette, Wyoming

CHEMICAL ANALYSIS OF TOPSOIL AND OVERBURDEN
AREA A, SECTION 5
N49000-E46000

February 17, 1976
Job No. 69-147

Depth, Feet	Lab No.	pH	Conductivity mmhos/cm	Saturation %	Calcium meq/Liter	Calcium meq/100 grams*	Magnesium meq/Liter	Magnesium meq/100 grams*	Sodium meq/Liter	Sodium meq/100 grams*	SAR	Texture**	Probable Subsurface Formation
0 - 3	53933	8.1	9.19	29.1	21.8	0.63	47.2	1.37	69.0	2.01	11.75	Loam	Brown Topsoil
3 - 14	53934	8.0	2.99	31.4	5.74	0.18	11.9	0.37	19.6	0.62	6.60	Sandy Loam	Brown Topsoil
14 - 17	53935	8.1	1.84	32.6	2.09	0.07	6.10	0.20	12.0	0.39	5.93	Loamy Sand	Brown Sandstone
17 - 21	53936	8.0	2.29	35.0	3.20	0.11	8.87	0.31	14.3	0.50	5.82	Sandy Loam	Brown Sandstone
21 - 31	53937	8.1	2.28	33.3	3.04	0.10	10.7	0.36	13.2	0.44	5.04	Sandy Loam	Brown Sandstone
31 - 47	53938	8.0	2.67	29.9	4.46	0.13	13.9	0.42	13.4	0.40	4.42	Sandy Loam	Brown Sandstone
47 - 57	53939	8.1	2.16	30.1	4.15	0.12	11.1	0.33	10.8	0.33	3.91	Loamy Sand	Brown Sandstone
57 - 64	53940	8.2	0.99	25.8	2.55	0.07	4.27	0.11	4.04	0.10	2.19	Loamy Sand	Brown Sandstone
64 - 67	53941	7.8	1.08	48.9	2.59	0.13	4.92	0.24	3.82	0.19	1.97	Clay	Gray Shale
67 - 77	53942	7.8	1.33	46.0	4.32	0.20	5.99	0.28	4.48	0.21	1.97	Silty Clay Loam	Gray Shale
77 - 87	53943	7.7	1.98	49.9	6.70	0.34	9.82	0.49	5.90	0.30	2.05	Clay Loam	Gray Shale
87 - 97	53944	8.0	0.85	71.3	2.12	0.15	2.51	0.18	4.30	0.31	2.83	Clay	Gray Shale
106 - 116 I.B.	53945	7.2	1.79	32.6	7.59	0.25	7.71	0.25	4.55	0.15	1.65	Sandy Loam	Gray Sandstone
120 - 130 I.B.	53946	7.7	2.05	31.7	8.78	0.28	8.13	0.26	6.82	0.22	2.35	Sandy Loam	Gray Sandstone
130 - 140 I.B.	53947	7.6	2.35	32.3	13.7	0.44	10.1	0.32	6.20	0.20	1.80	Sandy Loam	Gray Sandstone
140 - 150 I.B.	53948	7.8	2.47	28.3	12.6	0.35	11.1	0.31	7.26	0.20	2.11	Sandy Loam	Gray Sandstone
150 - 160 I.B.	53949	7.8	2.91	22.9	22.0	0.51	10.8	0.25	6.30	0.15	1.56	Loamy Sand	Gray Sandstone
160 - 170 I.B.	53950	8.0	3.14	23.5	23.2	0.56	13.2	0.32	6.60	0.16	1.55	Sandy Loam	Gray Sandstone
170 - 176 I.B.	53951	7.9	2.20	26.5	16.4	0.44	6.98	0.19	4.70	0.13	1.38	Loamy Sand	Gray Sandstone

*Oven Dry Soil
**U. S. Department of Agriculture Soil Textural Triangle

NORTHERN TESTING LABORATORIES, INC.
CONSULTING GEOTECHNICAL ENGINEERS
Great Falls, Billings, Montana - Boise, Idaho - Gillette, Wyoming

REVISED: March 23, 1976
February 17, 1976
Job No. 69-147

ANALYSIS OF TRACE ELEMENTS IN OVERBURDEN
AREA A, SECTION 5
WESTERN ENERGY COMPANY - COLSTRIP, MONTANA

All in Parts Per Million (-) Indicates Less Than Given Value

Sample Location	Depth, Ft.	Lab No.	Nitrate Nitrogen	Ammonia Nitrogen	Boron	Selenium	Molybdenum	Mercury	Zinc	Iron	Manganese	Copper	Cadmium	Lead	Nickel
45000- 46000	0 - 3	53933	-0.01	5.9	0.26	-0.02	0.70	0.024	6.83	7.9	4.67	0.74	0.01	0.6	0.29
	3 - 14	53934	-0.01	7.0	0.71	-0.02	0.34	0.013	1.53	10.2	8.08	0.36	0.01	0.3	0.16
	14 - 17	53935	-0.01	5.3	0.41	-0.02	0.23	0.011	0.35	6.2	2.59	0.36	0.35	0.7	0.21
	17 - 21	53936	-0.01	4.5	0.52	-0.02	0.20	0.020	15.9	6.6	4.85	0.30	0.01	0.3	0.24
	21 - 31	53937	-0.01	6.7	0.33	-0.02	-0.20	0.024	2.56	5.5	1.74	0.25	0.01	0.5	0.26
	31 - 47	53938	-0.01	5.0	0.37	0.02	0.20	0.019	6.82	12.2	4.08	0.37	-0.01	0.6	0.29
	47 - 57	53939	-0.01	14.8	0.22	-0.02	0.20	0.015	3.89	8.1	3.45	0.49	0.01	0.6	0.31
	57 - 64	53940	1.17	5.6	0.45	-0.02	-0.20	0.019	6.80	16.2	3.57	0.77	0.03	0.7	0.45
	64 - 67	53941	-0.01	12.0	0.22	0.02	0.57	0.082	11.8	110.0	12.2	2.58	0.03	4.6	1.92
	67 - 77	53942	-0.01	8.1	0.60	-0.02	0.72	0.070	14.4	93.5	10.9	3.68	0.04	5.6	2.51
	77 - 87	53943	-0.01	6.2	0.82	0.02	0.69	0.107	22.5	70.5	9.39	6.82	0.05	3.9	2.47
	87 - 97	53944	-0.01	11.2	1.19	0.02	0.42	0.146	7.30	39.9	2.64	5.89	0.02	7.4	1.51
I.B.	106 - 116	53945	-0.01	4.5	1.53	0.03	0.32	0.091	93.0	17.6	4.32	0.81	0.06	1.7	1.00
I.B.	120 - 130	53946	-0.01	-0.01	1.26	-0.02	0.28	0.059	522.0	3.7	3.30	0.16	0.20	-0.1	0.95
I.B.	130 - 140	53947	-0.01	5.6	0.67	-0.02	0.36	0.038	612.0	2.0	2.29	0.16	0.20	-0.1	0.96
I.B.	140 - 150	53948	-0.01	5.4	0.45	-0.02	0.42	0.049	585.0	1.9	2.80	0.18	0.19	-0.1	0.86
I.B.	150 - 160	53949	-0.01	5.0	0.37	-0.02	0.25	0.036	83.0	17.9	5.08	0.43	0.06	1.3	0.88
I.B.	160 - 170	53950	-0.01	3.6	0.71	-0.02	0.29	0.038	342.0	8.1	3.74	0.25	0.22	0.1	0.94
I.B.	170 - 176	53951	-0.01	2.5	0.74	-0.02	0.22	0.003	185.0	18.1	5.48	0.32	0.11	1.2	0.79

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CHEMICAL ANALYSIS OF TOPSOIL AND OVERBURDEN
AREA A, SECTION 5
WESTERN ENERGY COMPANY - COLSTRIP, MONTANA
N49000 - E48000

Job No. 69-147
February 24, 1976

Depth. Feet	Lab No.	pH	Conductivity mmhos/cm	Saturation %	Calcium meq/Liter	Calcium meq/100 grams*	Magnesium meq/Liter	Magnesium meq/100 grams*	Sodium meq/Liter	Sodium meq/100 grams*	SAR	Texture**	Probable Subsurface Formation
0 - 1	54043	7.7	0.59	29.8	4.19	0.12	2.82	0.08	0.45	0.01	0.24	Sandy Loam	Brown Topsoil
1 - 4	54044	8.2	0.51	32.4	1.00	0.03	3.95	0.13	1.33	0.04	0.85	Clay Loam	Brown Topsoil
4 - 8	54045	8.1	1.01	39.4	1.79	0.07	7.15	0.28	3.38	0.13	1.60	Silty Clay Loam	Brown Topsoil
8 - 11	54046	7.9	0.90	44.7	2.30	0.10	6.30	0.28	2.40	0.11	1.16	Silty Clay	Brown Clay
11 - 16	54047	8.0	0.74	38.7	2.11	0.08	5.95	0.23	1.55	0.06	0.77	Silty Clay Loam	Brown Clay
16 - 18	54048	8.0	0.73	37.1	1.80	0.07	5.41	0.20	1.20	0.04	0.63	Silty Clay Loam	Gray Shale
18 - 20	54049	8.2	0.77	34.1	2.49	0.08	5.51	0.19	1.15	0.04	0.58	Silt Loam	Brown Sandy Shale
20 - 27	54050	7.7	1.01	51.8	4.07	0.21	7.00	0.36	1.10	0.06	0.47	Silty Clay	Brown Shale
27 - 33	54051	7.8	1.21	35.2	5.58	0.20	8.04	0.28	1.37	0.05	0.53	Silt Loam	Brown Shale
33 - 40	54052	7.8	1.01	48.3	4.22	0.20	6.50	0.31	1.04	0.05	0.45	Silty Clay	Gray Shale
40 - 46	54053	8.1	1.08	30.9	3.37	0.10	7.99	0.25	1.20	0.04	0.50	Silt Loam	Gray Sandy Shale
46 - 53	54054	8.0	0.69	38.7	2.82	0.11	4.27	0.17	1.30	0.05	0.69	Silt Loam	Brown Shale
53 - 56	54055	7.9	1.06	32.9	4.17	0.14	7.00	0.23	1.93	0.06	0.82	Loam	Gray Sandy Shale
56 - 66	54056	7.8	1.72	30.9	6.19	0.19	8.10	0.25	5.20	0.16	1.95	Sandy Clay Loam	Gray Sandstone
66 - 71	54057	7.5	1.70	47.7	7.03	0.34	9.05	0.43	4.90	0.23	1.73	Clay Loam	Gray Shale
104 - 108 I.B.	54058	7.1	1.75	43.1	6.41	0.28	8.34	0.36	7.85	0.34	2.89	Clay Loam	Gray Shale
116 - 126 I.B.	54059	7.2	1.52	26.8	7.29	0.20	7.10	0.19	4.30	0.12	1.60	Loamy Sand	Gray Sandstone
126 - 136 I.B.	54060	7.4	1.58	30.6	8.02	0.25	6.32	0.19	4.65	0.14	1.74	Sand	Gray Sandstone
136 - 146 I.B.	54061	7.4	1.38	27.0	7.19	0.19	5.29	0.14	3.80	0.10	1.52	Loamy Sand	Gray Sandstone
146 - 156 I.B.	54062	7.7	1.30	28.5	6.54	0.19	4.36	0.12	3.55	0.10	1.52	Sand	Gray Sandstone
156 - 165 I.B.	54063	7.6	1.54	28.6	7.48	0.21	4.51	0.13	4.75	0.14	1.94	Sand	Gray Sandstone

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CONSULTING GEOTECHNICAL ENGINEERS
Great Falls, Billings, Montana - Boise, Idaho - Gillette, Wyoming

February 24, 1976
Job No. 69-147

ANALYSIS OF TRACE ELEMENTS IN OVERBURDEN
AREA A, SECTION 5
WESTERN ENERGY COMPANY - COLSTRIP, MONTANA

All in Parts Per Million (-) Indicates Less Than Given Value

Sample Location	Depth, Ft.	Lab No.	Nitrate Nitrogen	Ammonia Nitrogen	Boron	Selenium	Molydbenum	Mercury	Zinc	Iron	Manganese	Copper	Cadmium	Lead	Nickel
N-3000 -	0 - 1	54043	1.98	10.1	0.56	-0.02	-0.20	0.011	22.4	13.4	7.65	0.66	0.05	0.8	0.37
E 48000	1 - 4	54044	0.08	4.2	1.08	-0.02	-0.20	0.021	9.37	10.2	4.49	0.57	0.02	0.6	0.15
	4 - 8	54045	-0.01	5.6	0.78	-0.02	-0.20	0.028	14.3	12.8	5.15	0.41	0.02	1.4	0.12
	8 - 11	54046	0.62	5.0	0.52	-0.02	-0.20	0.045	14.7	21.8	5.39	1.85	0.04	1.2	0.35
	11 - 16	54047	0.39	6.2	0.56	-0.02	-0.20	0.024	2.94	10.5	1.90	0.94	0.04	1.2	0.12
	16 - 18	54048	0.04	10.9	0.26	-0.02	-0.20	0.055	1.70	28.1	1.85	3.37	0.01	3.4	0.47
	18 - 20	54049	-0.01	16.0	0.56	-0.02	-0.20	0.032	0.79	6.2	1.37	1.20	0.04	0.8	0.32
	20 - 27	54050	0.08	9.0	0.39	-0.02	0.27	0.063	23.2	46.9	7.83	2.79	0.04	4.3	1.43
	27 - 38	54051	0.04	8.7	0.20	-0.02	-0.20	0.047	4.56	18.6	2.95	1.65	0.04	1.7	0.75
	38 - 40	54052	0.23	8.4	0.56	-0.02	0.32	0.036	7.16	36.3	2.93	3.82	0.06	5.3	1.62
	40 - 46	54053	-0.01	5.3	0.36	-0.02	0.26	0.026	28.9	23.3	3.18	1.97	0.05	2.1	0.67
	46 - 53	54054	-0.01	4.5	0.16	-0.02	-0.20	0.032	34.2	16.6	8.23	1.07	0.06	1.7	0.60
	53 - 56	54055	0.04	3.4	0.10	-0.02	-0.20	0.032	4.75	37.5	4.84	1.04	0.04	2.1	0.79
	56 - 66	54056	-0.01	6.4	0.29	-0.02	0.51	0.052	77.2	39.5	4.65	2.36	0.08	3.7	1.75
	66 - 71	54057	-0.01	7.8	0.98	-0.02	0.80	0.063	12.2	73.5	10.5	3.25	0.06	3.8	0.83
I.B.	104 - 108	54058	0.43	4.8	2.29	-0.02	1.04	0.151	129.0	24.9	4.10	2.12	0.12	4.7	0.69
I.B.	116 - 126	54059	-0.01	3.6	1.70	-0.02	-0.20	0.036	216.0	12.4	5.06	0.67	0.13	2.0	0.69
I.B.	126 - 136	54060	0.17	2.9	1.11	-0.02	0.20	0.019	53.9	13.9	2.73	0.42	0.06	1.4	0.67
I.B.	136 - 146	54061	0.19	3.1	1.18	-0.02	-0.20	0.026	135.0	17.2	3.61	0.47	0.09	1.8	0.72
I.B.	146 - 156	54062	-0.01	2.8	0.43	-0.02	-0.20	0.019	42.3	14.3	1.79	0.58	0.05	1.3	0.67
I.B.	156 - 165	54063	-0.01	2.8	0.59	-0.02	-0.20	0.019	38.4	13.5	2.09	0.60	0.04	1.4	0.51

NORTHERN TESTING LABORATORIES, INC.
CONSULTING GEOTECHNICAL ENGINEERS
Great Falls, Billings, Montana - Boise, Idaho - Gillette, Wyoming

CHEMICAL ANALYSIS OF TOPSOIL AND OVERBURDEN
AREA A, SECTION 4
N49000-E50000
WESTERN ENERGY COMPANY - COLSTRIP, MONTANA

February 17, 1976
Job No. 69-147

pth. Feet	Lab No.	pH	Conductivity mmhos/cm	Saturation %	Calcium meq/Liter	Calcium meq/100 grams*	Magnesium meq/Liter	Magnesium meq/100 grams*	Sodium meq/Liter	Sodium meq/100 grams*	SAR	Texture**	Probable Subsurface Formation
0 - 3	53885	8.1	0.35	30.6	2.12	0.07	2.20	0.07	0.37	0.01	0.25	Loam	Brown Topsoil
3 - 8	53886	8.1	9.95	39.7	23.1	0.92	61.5	2.44	38.2	1.52	5.87	Silt Loam	Brown Sandy Clay
8 - 12	53887	7.8	3.79	50.4	28.1	1.42	24.6	1.24	5.96	0.30	1.16	Silty Clay	Brown Clay
12 - 15	53888	7.7	2.06	42.8	16.7	0.71	12.0	0.51	1.72	0.07	0.45	Silty Clay Loam	Brown Clay
15 - 20	53889	7.7	0.89	57.0	4.09	0.23	5.35	0.31	1.43	0.08	0.66	Clay	Brown Shale
20 - 25	53890	7.4	3.04	65.3	16.7	1.09	23.0	1.50	2.45	0.16	0.55	Clay	Gray Brown Shale
51 - 55 I.B.	53891	7.1	2.12	37.6	8.23	0.31	11.1	0.42	6.18	0.23	1.99	Loam	Gray Shale
55 - 60 I.B.	53892	7.7	2.10	25.1	12.1	0.30	9.01	0.23	4.62	0.12	1.42	Sandy Loam	Gray Sandstone
60 - 70 I.B.	53893	7.8	1.40	27.7	7.82	0.22	4.61	0.13	3.12	0.09	1.25	Sand	Gray Sandstone
70 - 80 I.B.	53894	7.4	1.50	32.7	8.17	0.27	4.08	0.13	3.71	0.12	1.50	Sand	Gray Sandstone
80 - 90 I.B.	53895	7.8	1.40	30.6	7.44	0.23	4.27	0.13	3.26	0.10	1.35	Sand	Gray Sandstone
90 - 97 I.B.	53896	7.2	2.45	28.0	13.6	0.38	9.73	0.27	5.99	0.17	1.75	Sand	Gray Sandstone
97 - 100 I.B.	53897	7.8	2.19	29.1	11.2	0.33	10.0	0.29	5.34	0.16	1.64	Sandy Clay Loam	Gray Sandstone

*Oven Dry Soil

**U. S. Department of Agriculture Soil Textural Triangle

NORTHERN TESTING LABORATORIES, INC.
CONSULTING GEOTECHNICAL ENGINEERS
Great Falls, Billings, Montana - Boise, Idaho - Gillette, Wyoming

ANALYSIS OF TRACE ELEMENTS IN OVERBURDEN
AREA A, SECTION 4
WESTERN ENERGY COMPANY - COLSTRIP, MONTANA

February 17, 1976
Job No. 69-147

All in Parts Per Million (-) Indicates Less Than Given Value

ample cation	Depth, Ft.	Lab No.	Nitrate Nitrogen	Ammonia Nitrogen	Boron	Selenium	Molybdenum	Mercury	Zinc	Iron	Manganese	Copper	Cadmium	Lead	Nickel
[illegible]	0 - 3	53885	1.00	10.9	0.16	-0.02	0.48	0.082	85.0	5.5	14.1	0.56	0.07	0.7	0.30
	3 - 8	53886	-0.01	14.0	1.60	-0.02	0.42	0.053	154.0	9.7	33.4	0.81	0.11	0.9	0.46
	8 - 12	53887	-0.01	14.6	0.49	-0.02	0.36	0.042	3.98	28.9	8.83	1.20	0.02	1.1	0.21
	12 - 15	53888	0.72	7.3	0.29	-0.02	0.26	0.074	1.64	29.9	16.1	0.88	0.02	1.1	0.25
	15 - 20	53889	-0.01	9.0	0.32	-0.02	0.39	0.125	1.41	19.3	3.90	1.79	0.02	1.6	0.30
	20 - 25	53890	0.39	18.6	0.43	-0.02	-0.20	0.138	12.1	17.8	13.1	1.83	0.04	2.3	0.77
1.B.	51 - 55	53891	-0.01	10.9	1.67	-0.02	1.58	0.140	17.5	84.8	5.64	1.24	0.03	3.9	0.48
1.B.	55 - 60	53892	0.22	9.0	1.47	-0.02	0.67	0.066	387.0	2.8	2.48	0.18	0.24	-0.1	0.37
1.B.	60 - 70	53893	-0.01	7.3	0.72	-0.02	0.46	0.049	241.0	10.6	3.29	0.33	0.14	1.5	0.72
1.B.	70 - 80	53894	-0.01	5.3	0.36	-0.02	0.36	0.042	34.9	11.2	1.24	0.28	0.02	1.5	0.42
1.B.	80 - 90	53895	-0.01	9.2	0.43	-0.02	0.34	0.051	156.0	19.8	2.43	0.51	0.09	1.3	0.65
1.B.	90 - 97	53896	-0.01	8.4	0.95	-0.02	0.40	0.082	152.0	26.5	3.29	0.52	0.08	1.8	1.00
1.B.	97 - 100	53897	-0.01	6.2	0.85	-0.02	0.46	0.104	199.0	39.3	6.34	1.73	0.11	3.8	1.25

NORTHERN TESTING LABORATORIES, INC.
CONSULTING GEOTECHNICAL ENGINEERS
Great Falls, Billings, Montana - Boise, Idaho - Gillette, Wyoming

CHEMICAL ANALYSIS OF TOPSOIL AND OVERBURDEN
AREA A, SECTION 4
N49000-E52000
WESTERN ENERGY COMPANY - COLSTRIP, MONTANA

February 17, 1976
Job No. 69-147

Depth, Feet	Lab No.	pH	Conductivity mmhos/cm	Saturation %	Calcium meq/Liter	Calcium meq/100 grams*	Magnesium meq/Liter	Magnesium meq/100 grams*	Sodium meq/Liter	Sodium meq/100 grams*	SAR	Texture**	Probable Subsurface Formation
0 - 2	53898	7.9	0.38	30.2	1.67	0.05	2.34	0.07	0.48	0.01	0.34	Sandy Loam	Brown Topsoil
2 - 5	53899	8.4	0.91	27.7	0.69	0.01	3.78	0.10	5.24	0.15	3.51	Loam	Lt. Brown Sandy Clay
5 - 9	53900	8.1	3.10	29.8	3.77	0.11	21.6	0.64	11.1	0.33	3.12	Silt Loam	Brown Clay
9 - 12	53901	8.3	0.60	30.5	0.83	0.03	3.73	0.11	2.10	0.06	1.39	Sandy Loam	Brown Sandstone
12 - 16	53902	8.2	0.45	49.1	0.93	0.05	3.11	0.15	1.10	0.05	0.77	Silty Clay Loam	Brown Shale
16 - 19	53903	8.2	0.50	30.8	1.40	0.04	2.83	0.09	1.16	0.04	0.80	Sandy Loam	Brown Sandstone
19 - 22	53904	8.0	0.51	32.2	1.95	0.06	2.93	0.09	1.15	0.04	0.74	Loam	Brown Sandy Shale
22 - 24	53905	7.6	1.34	27.6	7.84	0.22	8.29	0.23	1.40	0.04	0.49	Sandy Loam	Brown Sandstone
24 - 26	53906	7.8	0.85	27.5	3.11	0.09	4.49	0.12	2.20	0.06	1.13	Sandy Loam	Brown Sandstone
26 - 36	53907	7.6	1.76	32.5	8.69	0.28	11.2	0.36	1.95	0.06	0.62	Loam	Lt. Brown Sandy Shal
55 - 65 I.B.	53908	7.5	2.20	51.1	10.2	0.52	11.3	0.58	5.12	0.26	1.56	Clay	Gray Shale
65 - 75 I.B.	53909	7.5	2.31	40.5	13.3	0.54	12.2	0.49	5.24	0.21	1.47	Clay Loam	Gray Shale
75 - 80 I.B.	53910	7.4	2.09	34.0	10.7	0.36	10.1	0.34	5.58	0.19	1.73	Loam	Gray Sandy Shale
80 - 85 I.B.	53911	7.3	3.02	38.9	19.0	0.74	16.7	0.65	5.99	0.23	1.42	Clay Loam	Gray Sandy Shale

*Oven Dry Soil
**U. S. Department of Agriculture Soil Textural Triangle

NORTHERN TESTING LABORATORIES, INC.
CONSULTING GEOTECHNICAL ENGINEERS
Great Falls, Billings, Montana - Boise, Idaho - Gillette, Wyoming

ANALYSIS OF TRACE ELEMENTS IN OVERBURDEN
AREA A, SECTION 4
WESTERN ENERGY COMPANY - COLSTRIP, MONTANA

February 17, 1976
Job No. 69-147

All In Parts Per Million (-) Indicates Less Than Given Value

ample ocation	Depth, Ft.	Lab No.	Nitrate Nitrogen	Ammonia Nitrogen	Boron	Selenium	Molybdenum	Mercury	Zinc	Iron	Manganese	Copper	Cadmium	Lead	Nickel
[illegible]	0 - 2	53898	-0.01	6.4	0.39	-0.02	0.44	0.045	2.31	5.6	5.15	0.50	-0.01	0.4	0.09
[illegible]	2 - 5	53899	-0.01	7.6	0.16	-0.02	0.41	0.043	1.32	5.7	3.03	0.53	-0.01	0.4	0.07
	5 - 9	53900	-0.01	8.1	0.03	-0.02	0.36	0.032	4.14	8.8	6.27	0.60	-0.01	0.5	0.04
	9 - 12	53901	-0.01	7.0	0.16	-0.02	0.24	0.049	0.59	14.9	2.83	0.37	-0.01	0.7	0.05
	12 - 16	53902	-0.01	6.7	0.20	-0.02	0.27	0.057	1.48	10.7	4.70	0.48	-0.01	1.1	0.03
	16 - 19	53903	0.06	8.4	0.23	0.02	0.30	0.049	0.66	7.0	4.55	0.39	-0.01	0.8	0.03
	19 - 22	53904	-0.01	5.3	0.26	-0.02	0.24	0.055	0.36	8.3	8.08	0.46	-0.01	0.3	0.01
	22 - 24	53905	-0.01	6.7	0.20	-0.02	0.26	0.047	12.8	12.0	14.3	0.65	-0.01	0.4	0.15
	24 - 26	53906	-0.01	6.4	0.23	-0.02	-0.20	0.051	5.9	5.8	3.49	0.46	-0.01	0.6	-0.01
	26 - 36	53907	-0.01	8.1	0.16	-0.02	0.35	0.097	84.5	119.0	36.1	1.25	0.05	1.5	1.17
1.B.	58 - 68	53908	0.05	14.3	1.60	-0.02	0.42	0.095	139.0	32.0	7.86	2.34	0.10	6.6	1.43
1.B.	68 - 75	53909	-0.01	11.8	0.78	-0.02	0.45	0.118	138.0	40.5	14.2	2.01	0.08	3.9	1.11
1.B.	75 - 80	53910	-0.01	7.6	1.18	0.02	0.33	0.070	94.0	36.1	15.3	1.36	0.05	3.2	0.76
1.B.	80 - 85	53911	-0.01	8.4	1.70	-0.02	0.36	0.085	350.0	2.5	6.00	0.27	0.19	0.1	1.32

NORTHERN TESTING LABORATORIES, INC.
CONSULTING GEOTECHNICAL ENGINEERS
Great Falls, Billings, Montana - Boise, Idaho - Gillette, Wyoming

CHEMICAL ANALYSIS OF TOPSOIL AND OVERBURDEN
AREA A, SECTION 4
N50000-E52000
WESTERN ENERGY COMPANY - COLSTRIP, MONTANA

February 17, 1976
Job No. 69-147

Feet	Lab No.	pH	Conductivity mmhos/cm	Saturation %	Calcium meq/Liter	Calcium meq/100 grams*	Magnesium meq/Liter	Magnesium meq/100 grams*	Sodium meq/Liter	Sodium meq/100 grams*	SAR	Texture**	Probable Subsurface Formation
- 10	53912	8.0	0.50	32.8	1.85	0.06	3.36	0.11	0.95	0.03	0.59	Clay Loam	Brown Topsoil
- 16	53913	8.0	8.40	26.1	23.7	0.62	50.4	1.32	56.9	1.49	9.35	Sandy Loam	Brown Topsoil
- 20	53914	8.2	10.2	32.2	25.7	0.83	37.5	1.21	64.0	2.06	11.39	Clay Loam	Brown Sandy Shale
- 22	53915	8.1	5.75	28.0	21.3	0.60	39.9	1.12	28.1	0.79	5.08	Sandy Loam	Brown Sandstone
- 26	53916	8.0	3.51	29.1	15.4	0.45	23.4	0.68	12.5	0.36	2.84	Sandy Loam	Brown Sandstone
- 29	53917	6.8	1.70	71.7	9.88	0.71	9.49	0.68	2.84	0.20	0.91	Clay	Brown Shale
- 61 I.B.	53913	6.5	2.31	51.7	10.5	0.54	14.9	0.77	3.62	0.19	1.02	Silty Clay Loam	Gray Shale
- 71 I.B.	53919	8.0	2.07	25.9	6.69	0.17	10.7	0.28	6.98	0.18	2.37	Sandy Loam	Gray Sandstone
- 76 I.B.	53920	7.1	3.15	44.9	19.5	0.88	19.5	0.88	6.40	0.29	1.45	Silty Clay	Gray Shale

*Oven Dry Soil
**U. S. Department of Agriculture Soil Textural Triangle

NORTHERN TESTING LABORATORIES, INC.
CONSULTING GEOTECHNICAL ENGINEERS
Great Falls, Billings, Montana - Boise, Idaho - Gillette, Wyoming

February 17, 1976
Job No. 69-147

ANALYSIS OF TRACE ELEMENTS IN OVERBURDEN
AREA A, SECTION 4
WESTERN ENERGY COMPANY - COLSTRIP, MONTANA

All in Parts Per Million (-) Indicates Less Than Given Value

Sample Location	Depth, Ft.	Lab No.	Nitrate Nitrogen	Ammonia Nitrogen	Boron	Selenium	Molybdenum	Mercury	Zinc	Iron	Manganese	Copper	Cadmium	Lead	Nickel
[illegible]	0 - 10	53912	2.94	6.7	1.31	-0.02	0.54	0.047	173.0	21.6	37.9	1.23	0.11	0.9	0.39
	10 - 16	53913	-0.01	4.8	0.78	-0.02	0.62	0.040	4.68	9.5	3.43	0.79	-0.01	0.5	0.05
	16 - 20	53914	-0.01	5.0	0.72	-0.02	0.50	0.043	11.4	26.6	10.0	1.05	-0.01	1.0	0.09
	20 - 22	53915	0.28	6.2	0.29	-0.02	0.20	0.032	2.26	14.3	4.98	0.56	-0.01	0.5	0.05
	22 - 26	53916	-0.01	5.9	0.29	-0.02	0.40	0.078	378.0	2.3	11.0	0.45	0.22	0.2	0.43
	26 - 29	53917	-0.01	12.6	0.52	-0.02	0.21	0.130	53.2	56.4	4.52	6.54	0.04	2.0	-0.01
1.B.	51 - 61	53918	-0.01	17.6	2.49	-0.02	0.20	0.243	48.0	61.7	3.48	3.79	0.05	3.2	1.15
1.B.	61 - 71	53919	-0.01	9.0	0.56	-0.02	0.66	0.069	11.5	33.4	3.40	1.70	-0.01	1.6	1.01
1.B.	71 - 76	53920	-0.01	11.2	2.19	0.02	0.92	0.080	47.6	65.2	6.66	2.98	0.06	5.5	1.89

NORTHERN TESTING LABORATORIES, INC.
CONSULTING GEOTECHNICAL ENGINEERS
Great Falls, Billings, Montana - Boise, Idaho - Gillette, Wyoming

January 9, 1976

Job No. 69-147

CHEMICAL ANALYSIS OF TOPSOIL AND OVERBURDEN
AREA A, SECTION 32
51000N, 48000E
WESTERN ENERGY COMPANY
COLSTRIP, MONTANA

Depth, Feet	Lab No.	pH	Conductivity mmhos/cm	Saturation %	Calcium meq/Liter	Calcium meq/100 grams*	Magnesium meq/Liter	Magnesium meq/100 grams*	Sodium meq/Liter	Sodium meq/100 grams*	SAR	Texture**	Probable Subsurface Formation
0'- 10'	52529	8.0	5.45	38.2	22.8	0.87	32.1	1.23	27.1	1.04	5.17	Loam	Lt. brown silt
10'- 20'	52530	8.0	4.55	31.9	21.0	0.67	26.0	0.83	19.3	0.62	3.98	Loam	Lt. brown silt
20'- 30'	52531	8.0	3.15	42.1	16.4	0.69	17.2	0.72	8.61	0.36	2.10	Clay Loam	Lt. brown clay
30'- 35'	52532	7.8	2.05	53.2	8.10	0.43	9.99	0.53	5.05	0.27	1.68	Silty Clay	Lt. brown clay
35'- 40'	52533	7.7	2.80	43.5	14.3	0.62	16.1	0.70	5.26	0.23	1.35	Clay loam	Dk. gray sandy shale
40'- 45'	52534	7.8	3.10	53.4	15.1	0.81	21.6	1.15	5.59	0.30	1.30	Silty Clay loam	Dk. gray shale
45'- 50'	52535	8.2	1.30	28.3	3.76	0.11	6.83	0.19	3.35	0.09	1.46	Loam	Lt. brown sandy shale
50'- 60'	52536	8.2	1.15	28.6	3.28	0.09	6.15	0.18	2.66	0.08	1.23	Sandy loam	Brown sandstone
60'- 70'	52537	8.0	1.75	44.9	4.00	0.18	10.3	0.46	5.19	0.23	1.94	Loam	Gray-brown sandy shale
70'- 80'	52538	8.0	1.80	28.2	4.73	0.13	8.77	0.25	5.87	0.17	2.26	Sandy loam	Gray sandstone
80'- 90'	52539	7.9	2.20	33.5	7.41	0.29	8.14	0.31	9.11	0.35	3.27	Silt loam	Gray shale
90'-100'	52540	7.9	2.05	39.7	7.32	0.29	7.34	0.29	7.89	0.31	2.91	Sandy clay loam	Gray sandstone
1.B.140'-150'	52541	7.9	1.57	33.5	5.96	0.20	5.43	0.18	5.14	0.17	2.15	Loam	Gray sandy shale
1.B.150'-160'	52542	7.9	1.65	27.2	7.51	0.20	7.43	0.20	5.84	0.16	2.14	Sandy loam	Gray sandstone
1.B.160'-170'	52543	7.3	2.20	27.9	9.48	0.26	9.52	0.27	7.31	0.20	2.37	Sandy loam	Gray sandstone
1.B.170'-180'	52544	7.8	1.80	26.5	6.02	0.16	6.91	0.18	6.56	0.17	2.58	Sandy loam	Gray sandstone

*Oven-dry soil

**U.S. Department of Agriculture Soil Textural Triangle

NORTHERN TESTING LABORATORIES, INC.
CONSULTING GEOTECHNICAL ENGINEERS
Great Falls, Billings, Montana - Boise, Idaho - Gillette, Wyoming

January 9, 1976

Job No. 69-147

ANALYSIS OF TRACE ELEMENTS IN OVERBURDEN
AREA A, SECTION 32
WESTERN ENERGY COMPANY
COLSTRIP, MONTANA
All In Parts Per Million
(-) Indicates Less Than Given Value

Sample Location	Depth	Lab No.	Nitrate Nitrogen	Ammonia Nitrogen	Boron	Selenium	Molybdenum	Mercury	Zinc	Iron	Manganese	Copper	Cadmium	Lead	Nickel
ALL	0'- 10'	52529	0.33	16.8	0.33	-0.02	0.41	0.005	1.40	4.9	1.80	1.19	-0.01	0.56	0.18
	10'- 20'	52530	0.22	16.8	0.05	-0.02	0.30	0.008	7.43	6.9	4.27	1.21	-0.01	0.33	0.07
Area A	20'- 30'	52531	0.22	16.1	0.35	-0.02	0.32	0.014	14.4	22.2	9.11	4.43	-0.01	1.20	0.16
Sect. 32	30'- 35'	52532	0.22	18.3	0.00	-0.02	0.44	0.017	5.89	50.3	10.7	1.72	-0.01	3.96	0.58
51000N	35'- 40'	52533	0.33	19.7	0.05	-0.02	0.50	0.022	5.72	76.7	10.7	1.50	0.01	2.96	0.53
48000E	40'- 45'	52534	0.17	22.6	0.00	-0.02	0.78	0.029	6.05	38.4	6.38	2.63	0.03	3.82	1.66
	45'- 50'	52535	0.39	12.9	0.00	-0.02	0.25	0.014	2.95	8.0	5.00	0.73	-0.01	0.12	0.12
	50'- 60'	52536	0.17	15.4	0.00	-0.02	-0.20	0.012	1.90	5.8	1.75	0.56	-0.01	0.44	0.06
	60'- 70'	52537	0.17	16.5	0.00	-0.02	0.32	0.016	4.41	27.7	2.78	1.25	0.01	1.86	0.50
	70'- 80'	52538	1.39	14.3	0.00	-0.02	0.22	0.023	1.75	18.8	1.33	0.24	-0.01	0.97	0.46
	80'- 90'	52539	0.17	15.0	0.00	-0.02	0.42	0.029	3.68	34.0	3.01	1.37	0.01	2.86	1.33
	90'-100'	52540	1.33	16.1	0.10	-0.02	0.55	0.020	6.44	22.1	1.56	1.48	0.01	2.26	1.35
I.B.	140'-150'	52541	0.17	12.5	0.30	-0.02	0.33	0.019	6.24	21.7	1.66	3.62	0.02	1.85	0.82
I.B.	150'-160'	52542	0.17	15.8	0.00	-0.02	0.29	0.016	15.0	26.7	1.87	2.09	0.02	1.03	0.67
I.B.	160'-170'	52543	0.22	15.8	0.10	-0.02	0.41	0.015	2.53	25.6	2.04	1.52	0.01	1.63	1.33
I.B.	170'-180'	52544	0.17	20.0	0.05	-0.02	0.28	0.015	2.78	23.8	1.55	1.57	0.01	1.14	0.63

Certified ______________________

NORTHERN TESTING LABORATORIES, INC.
CONSULTING GEOTECHNICAL ENGINEERS
Great Falls, Billings, Montana - Boise, Idaho - Gillette, Wyoming

January 9, 1976

Job No. 65-147

CHEMICAL ANALYSIS OF TOPSOIL AND OVERBURDEN
AREA A, SECTION 32
52000N, 47000E
WESTERN ENERGY COMPANY
COLSTRIP, MONTANA

Depth, Feet	Lab No.	pH	Conductivity mmhos/cm	Saturation %	Calcium meq/Liter	Calcium meq/100 grams*	Magnesium meq/Liter	Magnesium meq/100 grams*	Sodium meq/Liter	Sodium meq/100 grams*	SAR	Texture**	Probable Subsurface Formation
0'- 5'	52510	8.1	6.20	54.8	23.6	1.29	40.5	2.22	29.7	1.63	5.25	Silty clay loam	Lt. brown clay
5'- 10'	52511	8.2	8.50	52.9	23.2	1.23	58.9	3.12	52.6	2.78	8.21	Silty clay loam	Lt. brown clay
10'- 15'	52512	8.3	5.30	40.8	11.6	0.47	18.0	0.73	34.2	1.40	8.89	Silt loam	Lt. brown silt
15'- 20'	52513	7.2	6.50	85.8	20.3	1.74	26.4	2.27	42.9	3.68	8.88	Clay	Lt. brown clay
20'- 30'	52514	8.1	3.15	86.5	2.31	0.20	2.67	0.23	24.2	2.09	15.34	Silty clay	Gray shale
30'- 35'	52515	8.3	1.90	103.7	0.83	0.09	0.32	0.03	18.3	1.90	24.13	Silty clay	Gray-brown shale
35'- 40'	52516	8.2	2.90	88.3	1.15	0.10	0.68	0.06	27.6	2.44	28.85	Clay loam	Dk. brown shale
40'- 50'	52517	8.6	1.65	95.8	0.45	0.04	0.10	0.01	15.4	1.48	29.37	Clay loam	Gray-brown shale
50'- 60'	52518	8.6	1.30	103.6	0.41	0.04	0.03	-0.01	13.0	1.35	27.72	Silty clay loam	Brown shale
60'- 63'	52519	7.0	4.95	64.1	5.54	0.36	3.15	0.20	50.0	3.21	23.99	Clay	Dk. gray sandy shale
63'- 70'	52520	8.4	1.90	56.2	0.60	0.03	0.19	0.01	18.6	1.05	29.59	Silty Clay	Lt. gray shale
70'- 80'	52521	8.2	3.50	31.5	1.40	0.04	0.63	0.02	31.5	0.99	31.27	Silty clay loam	Lt. gray shale
80'- 90'	52522	8.4	5.10	35.9	1.12	0.04	0.94	0.03	50.6	1.82	49.86	Silty clay	Gray shale
90'-100'	52523	7.6	3.65	41.1	4.26	0.18	2.41	0.10	30.4	1.25	16.65	Silty clay loam	Gray shale
100'-110'	52524	8.3	1.90	40.2	1.30	0.05	1.00	0.04	16.9	0.68	15.76	Silty clay	Gray shale
110'-120'	52525	8.4	1.85	26.0	1.34	0.03	0.59	0.02	16.2	0.42	16.49	Loam	Gray sandy shale
120'-130'	52526	8.4	1.70	28.0	1.42	0.04	0.69	0.02	14.2	0.40	13.83	Sandy loam	Gray sandstone
130'-140'	52527	7.8	1.95	32.1	3.17	0.10	2.19	0.07	14.5	0.47	8.86	Sandy loam	Dk. gray sandstone
140'-150'	52528	8.0	1.55	29.4	2.47	0.07	2.07	0.06	10.3	0.30	6.84	Loamy sand	Gray sandstone

*Oven-dry soil

**U. S. Department of Agriculture Soil Textural Triangle

NORTHERN TESTING LABORATORIES, INC.
CONSULTING GEOTECHNICAL ENGINEERS
Great Falls, Billings, Montana - Boise. Idaho - Gillette, Wyoming

ANALYSIS OF TRACE ELEMENTS IN OVERBURDEN
AREA A, SECTION 32
52000N, 47000E
WESTERN ENERGY COMPANY
COLSTRIP, MONTANA
All In Parts Per Million
(-) Indicates Less Than Given Value

January 9, 1976

Job No. 69-147

Sample Location	Depth	Lab No.	Nitrate Nitrogen	Ammonia Nitrogen	Boron	Selenium	Molybdenum	Mercury	Zinc	Iron	Manganese	Copper	Cadmium	Lead	Nickel
ALL	0'- 5'	52510	0.00	22.9	0.84	0.03	0.21	0.028	10.2	5.1	2.65	1.51	0.03	1.3	0.19
	5'- 10'	52511	0.22	18.3	0.00	-0.02	0.31	0.016	5.46	7.3	1.67	1.01	0.02	1.7	0.13
Area A	10'- 15'	52512	0.61	15.4	0.40	-0.02	0.20	0.016	2.92	7.0	2.78	1.48	-0.01	0.9	0.23
Sect. 32	15'- 20'	52513	0.89	19.3	0.69	-0.02	0.21	0.059	2.67	23.9	1.87	2.44	0.02	2.1	0.43
52000N	20'- 30'	52514	0.22	23.3	0.60	-0.03	-0.20	0.067	8.57	33.9	1.30	9.45	0.02	4.5	1.29
47000E	30'- 35'	52515	0.11	29.4	1.14	-0.02	0.65	0.032	4.40	48.0	8.56	2.68	0.01	4.6	1.55
	35'- 40'	52516	0.39	31.9	0.64	-0.02	0.70	0.043	5.03	47.8	13.9	2.53	0.01	1.8	2.04
	40'- 50'	52517	0.22	32.6	0.30	-0.02	0.52	0.024	4.79	36.4	4.13	1.91	0.01	3.6	1.87
	50'- 60'	52518	0.11	37.8	0.05	-0.02	0.59	0.017	2.53	37.4	6.20	1.57	0.01	3.2	1.63
	60'- 63'	52519	2.50	25.4	4.61	-0.02	0.39	0.008	6.23	67.9	3.95	3.08	0.01	3.8	2.62
	63'- 70'	52520	1.00	32.2	0.45	-0.02	1.20	0.017	2.76	48.4	6.72	3.28	0.01	4.7	0.70
	70'- 80'	52521	0.17	21.1	0.05	-0.02	1.10	0.014	2.27	46.5	5.77	2.58	-0.01	2.6	0.82
	80'- 90'	52522	0.28	20.4	0.05	-0.02	0.57	0.022	4.07	39.3	4.02	1.88	-0.01	9.2	0.93
	90'-100'	52523	0.28	19.3	0.69	-0.02	0.97	0.027	2.26	40.4	5.21	2.15	-0.01	3.6	1.34
	100'-110'	52524	0.06	26.9	0.20	-0.02	0.53	0.025	2.90	38.5	3.97	3.11	0.01	4.6	0.88
	110'-120'	52525	0.33	14.0	0.35	-0.02	0.43	0.008	1.88	27.7	2.00	0.66	-0.01	1.6	0.81
	120'-130'	52526	0.00	19.0	0.00	0.02	0.42	0.018	2.76	17.4	1.30	0.36	-0.01	1.3	0.69
	130'-140'	52527	0.11	15.0	0.00	-0.02	0.33	0.037	2.39	19.6	1.81	0.42	-0.01	0.7	0.35
	140'-150'	52528	0.06	16.5	0.00	-0.02	0.37	0.017	3.27	18.9	1.35	0.79	-0.01	1.1	0.84

Certified________________________

NORTHERN TESTING LABORATORIES, INC.
CONSULTING GEOTECHNICAL ENGINEERS
Great Falls, Billings, Montana - Boise, Idaho - Gillette, Wyoming

CHEMICAL ANALYSIS OF TOPSOIL AND OVERBURDEN
AREA A, SECTION 32
52000N-47000E
WESTERN ENERGY COMPANY - COLSTRIP, MONTANA

January 19, 1976
Job No. 69-147

epth, Feet-	Lab No.	pH	Conductivity mmhos/cm	Saturation %	Calcium meq/Liter	Calcium meq/100 grams*	Magnesium meq/Liter	Magnesium meq/100 grams*	Sodium meq/Liter	Sodium meq/100 grams*	SAR	Texture**	Probable Subsurface Formation
85 - 195 I.B.	52956	7.1	2.80	38.0	13.0	0.49	11.9	0.45	9.85	0.37	2.79	Silt Loam	Gray Sandy Shale
95 - 205 I.B.	52957	7.2	3.20	31.8	15.9	0.51	18.4	0.59	9.04	0.29	2.18	Sandy Loam	Gray Sandstone
05 - 215 I.B.	52958	7.4	2.25	51.3	6.40	0.33	7.94	0.41	11.3	0.58	4.22	Silt Loam	Gray Shale
5 - 225 I.B.	52959	7.8	2.05	30.3	6.96	0.21	8.74	0.26	8.23	0.25	2.94	Sandy Loam	Gray Sandstone
25 - 235 I.B.	52960	7.9	1.80	33.9	5.07	0.17	6.61	0.22	8.49	0.29	3.51	Loam	Gray Sandy Shale

*Oven Dry Soil
**U. S. Department of Agriculture Soil Textural Triangle

NORTHERN TESTING LABORATORIES, INC.
CONSULTING GEOTECHNICAL ENGINEERS
Great Falls, Billings, Montana - Boise, Idaho - Gillette, Wyoming

ANALYSIS OF TRACE ELEMENTS IN OVERBURDEN
AREA A, SECTION 32
WESTERN ENERGY COMPANY - COLSTRIP, MONTANA

January 19, 1976
Job No. 69-147

All In Parts Per Million (-) Indicates Less Than Given Value

Sample Location	Depth.Ft.	Lab No.	Nitrate Nitrogen	Ammonia Nitrogen	Boron	Selenium	Molybdenum	Mercury	Zinc	Iron	Manganese	Copper	Cadmium	Lead	Nickel
50000N- 47000E	185-195 IB	52956	0.33	20.4	0.69	-0.02	0.30	0.014	5.22	33.3	2.54	1.69	0.02	3.3	1.06
	195-205 IB	52957	0.28	18.3	0.45	0.02	0.24	0.035	2.66	60.0	5.10	2.65	-0.01	2.8	0.98
	205-215 IB	52958	0.33	19.0	2.23	0.02	0.29	0.051	24.7	52.7	3.41	6.82	0.04	12.4	2.92
	215-225 IB	52959	0.28	15.0	0.60	-0.02	0.25	0.007	6.47	48.4	4.35	3.58	-0.01	4.2	0.92
	225-235 IB	52960	0.28	22.2	0.69	0.03	0.31	0.013	3.19	58.0	5.19	2.69	0.01	4.1	1.26

NORTHERN TESTING LABORATORIES, INC.
CONSULTING GEOTECHNICAL ENGINEERS
Great Falls, Billings, Montana - Boise, Idaho - Gillette, Wyoming

CHEMICAL ANALYSIS OF TOPSOIL AND OVERBURDEN
AREA A, SECTION 32
53000N-48000E
WESTERN ENERGY COMPANY - COLSTRIP, MONTANA

January 19, 1976
Job No. 69-147

Depth, Feet	Lab No.	pH	Conductivity mmhos/cm	Saturation %	Calcium meq/Liter	Calcium meq/100 grams*	Magnesium meq/Liter	Magnesium meq/100 grams*	Sodium meq/Liter	Sodium meq/100 grams*	SAR	Texture**	Probable Subsurface Formation
0 - 5	52885	8.1	5.50	33.0	25.6	0.84	37.2	1.23	23.4	0.77	4.18	Silt Loam	Lt. Brown Topsoil
5 - 10	52886	8.3	5.10	37.3	23.6	0.88	30.2	1.13	25.4	0.95	4.90	Silty Clay Loam	Lt. Brown Clay
10 - 15	52887	8.0	3.70	41.4	13.4	0.55	21.4	0.87	17.7	0.73	4.24	Clay Loam	Lt. Brown Clay
15 - 17	52888	8.2	3.50	42.4	8.60	0.36	20.3	0.86	18.9	0.80	4.97	Silty Clay Loam	Lt. Brown Shale
17 - 19	52889	7.8	3.30	53.2	7.84	0.42	18.2	0.97	17.7	0.94	4.91	Silty Clay	Greenish-gray Shale
19 - 21	52890	7.4	3.20	68.9	9.05	0.62	16.9	1.16	16.6	1.14	4.61	Silty Clay	Lt. Brown Shale
21 - 26	52891	8.0	3.50	35.0	8.74	0.31	15.6	0.55	21.5	0.75	6.16	Silt Loam	Brown Shale
26 - 28	52892	8.0	2.60	68.8	3.99	0.27	12.8	0.88	16.0	1.10	5.52	Clay	Gray Shale
28 - 32	52893	8.3	2.25	31.6	3.52	0.11	8.31	0.26	16.3	0.52	6.70	Sandy Loam	Lt. Brown Sandstone
32 - 35	52894	8.0	2.70	51.0	3.99	0.20	9.63	0.49	18.1	0.92	6.94	Silty Clay Loam	Lt. Brown Shale
35 - 45	52895	7.6	3.70	42.9	8.27	0.39	18.3	0.86	21.4	1.00	5.87	Silty Clay	Gray Shale
45 - 55	52896	7.8	3.60	34.5	10.3	0.36	15.8	0.55	23.7	0.82	6.56	Silt Loam	Gray Shale
55 - 65	52897	8.0	2.80	31.9	5.93	0.19	8.72	0.28	19.3	0.62	7.13	Loam	Gray Sandy Shale
65 - 75	52898	7.9	3.50	80.3	7.80	0.63	13.6	1.09	23.8	1.91	7.28	Silt Loam	Gray Sandy Shale
75 - 85	52899	8.0	2.95	44.1	5.79	0.26	8.41	0.37	21.2	0.93	7.96	Silt Loam	Gray Shale
85 - 92	52900	7.2	4.50	64.4	18.9	1.22	18.3	1.18	25.4	1.64	5.89	Clay	Gray Shale
117 - 127 I.B.	52901	7.3	2.20	49.9	6.92	0.35	8.34	0.42	11.0	0.55	3.98	Silty Clay Loam	Dk. Gray Shale
127 - 137 I.B.	52902	7.3	3.00	29.9	15.0	0.45	15.7	0.47	10.2	0.31	2.60	Loam	Dk. Gray Sandy Shale
137 - 147 I.B.	52903	7.6	2.05	30.3	8.72	0.26	9.37	0.28	7.13	0.22	2.37	Sandy Loam	Gray Sandstone
147 - 157 I.B.	52904	7.3	1.90	30.8	6.80	0.21	7.81	0.24	8.59	0.26	3.18	Sandy Loam	Gray Sandstone
157 - 162 I.B.	52905	7.8	1.55	36.2	3.81	0.14	4.62	0.17	7.61	0.28	3.71	Silt Loam	Gray Shale

*Oven Dry Soil
**U. S. Department of Agriculture Soil Textural Triangle

NORTHERN TESTING LABORATORIES, INC.
CONSULTING GEOTECHNICAL ENGINEERS
Great Falls, Billings, Montana- Boise, Idaho - Gillette, Wyoming

CHEMICAL ANALYSIS OF TOPSOIL AND OVERBURDEN
AREA A, SECTION 32
54000N-47000E
WESTERN ENERGY COMPANY - COLSTRIP, MONTANA

January 19, 1976
Job No. 69-147

Depth, Feet	Lab No.	pH	Conductivity mmhos/cm	Saturation %	Calcium meq/Liter	Calcium meq/100 grams*	Magnesium meq/Liter	Magnesium meq/100 grams*	Sodium meq/Liter	Sodium meq/100 grams*	SAR	Texture**	Probable Subsurface Formation
0 - 2	52927	7.4	2.35	42.8	20.7	0.89	8.90	0.38	0.54	0.02	0.14	Silt Loam	Lt. Brown Topsoil
2 - 6	52928	7.6	7.10	74.3	22.7	1.69	57.1	4.24	37.6	2.79	5.95	Clay	Lt. Brown Topsoil
6 - 8	52929	8.1	7.00	51.6	22.0	1.14	47.7	2.46	40.8	2.11	6.91	Silt Loam	Brown Clay
8 - 11	52930	8.0	6.40	58.6	16.1	0.94	38.8	2.27	41.3	2.42	7.88	Silty Clay	Lt. Brown Clay
11 - 14	52931	7.8	6.25	40.6	24.5	0.99	41.3	1.68	34.7	1.41	6.05	Silt Loam	Lt. Brown Shale
14 - 17	52932	7.4	6.50	52.8	21.6	1.14	41.3	2.18	38.6	2.04	6.88	Clay Loam	Lt. Brown Shale
17 - 19	52933	7.8	5.95	55.2	19.7	1.02	30.6	1.59	38.8	2.02	7.74	Silty Clay Loam	Yellow-Brown Shale
19 - 21	52934	8.0	4.50	34.9	5.74	0.20	18.1	0.63	34.7	1.21	10.05	Silt Loam	Lt. Brown Shale
21 - 27	52935	7.9	4.60	32.7	9.20	0.30	11.2	0.37	39.4	1.29	12.34	Loam	Yellow-Brown Sandy Shale
27 - 31	52936	7.9	6.50	67.8	19.0	1.29	17.6	1.19	52.5	3.56	12.27	Silty Clay	Lt. Brown Shale
31 - 36	52937	8.1	3.60	86.7	2.54	0.22	2.60	0.23	38.3	3.32	23.89	Silty Clay	Greenish Gray Shale
36 - 46	52938	8.1	2.50	94.6	1.11	0.11	0.87	0.03	25.1	2.37	25.23	Silty Clay	Brownish Gray Shale
46 - 56	52939	8.3	2.20	100.1	0.65	0.07	0.47	0.05	22.4	2.24	29.93	Silty Clay	Brownish Gray Shale
56 - 66	52940	8.1	3.10	66.4	1.00	0.07	0.76	0.05	33.9	2.25	36.14	Loam	Lt. Brown Shale
66 - 76	52941	6.4	6.80	58.9	13.5	0.80	7.31	0.43	66.4	3.91	20.58	Clay	Brownish Black Sandy Shale
76 - 86	52942	8.2	2.20	54.8	1.54	0.08	0.85	0.05	22.5	1.23	20.58	Silty Clay Loam	Gray Shale
86 - 96	52943	8.2	2.70	35.2	0.37	0.03	0.64	0.02	30.7	1.08	35.33	Silty Clay	Gray Shale
96 - 106	52944	8.0	2.50	34.0	0.82	0.03	0.68	0.02	27.1	0.94	31.29	Silty Clay Loam	Gray Shale
106 - 116	52945	8.0	2.50	47.5	0.91	0.04	0.82	0.04	27.2	1.29	29.24	Silty Clay	Gray Shale
116 - 126	52946	8.0	2.80	44.1	1.30	0.06	1.14	0.05	28.6	1.26	25.69	Silty Clay Loam	Gray Shale
126 - 136	52947	7.6	3.25	43.7	3.19	0.14	2.53	0.11	31.2	1.36	18.45	Silty Clay Loam	Gray Shale
136 - 146	52948	7.9	2.70	30.0	1.32	0.05	1.53	0.05	26.2	0.79	20.24	Silt Loam	Gray Shale
146 - 156	52949	7.9	2.40	44.5	1.83	0.08	1.32	0.06	23.0	1.02	18.33	Silty Clay	Gray Shale
156 - 159	52950	6.3	5.40	60.0	14.3	0.86	8.33	0.50	48.2	2.89	14.33	Loam	Black Sandy Shale
183 - 190 I.B.	52951	7.0	1.70	53.4	4.26	0.23	4.31	0.23	11.9	0.64	5.75	Silt Loam	Gray Shale
190 - 200 I.B.	52952	7.4	1.65	42.9	4.90	0.21	5.31	0.23	9.22	0.40	4.08	Silt Loam	Gray Shale
200 - 210 I.B.	52953	7.9	1.15	30.2	2.69	0.02	3.15	0.03	6.09	0.06	3.56	Sandy Loam	Gray Sandstone
210 - 220 I.B.	52954	7.7	1.05	29.1	2.82	0.08	3.14	0.09	4.98	0.14	2.88	Sandy Loam	Gray Sandstone
220 - 230 I.B.	52955	7.7	1.25	28.6	3.32	0.10	3.23	0.09	7.10	0.20	3.92	Loamy Sand	Gray Sandstone

*Oven Dry Soil **U. S. Department of Agriculture Soil Textural Triangle

NORTHERN TESTING LABORATORIES, INC.
CONSULTING GEOTECHNICAL ENGINEERS
Great Falls, Billings, Montana - Boise, Idaho - Gillette, Wyoming

ANALYSIS OF TRACE ELEMENTS IN OVERBURDEN
AREA A, SECTION 32
WESTERN ENERGY COMPANY - COLSTRIP, MONTANA

January 19, 1976
Job No. 69-147

All In Parts Per Million (-) Indicates Less Than Given Value

Sample Location	Depth, Ft.	Lab No.	Nitrate Nitrogen	Ammonia Nitrogen	Boron	Selenium	Molybdenum	Mercury	Zinc	Iron	Manganese	Copper	Cadmium	Lead	Nickel
53000N- 48000E	0 - 5	52885	0.72	13.2	3.92	0.03	0.21	0.062	1.86	9.4	6.65	1.92	0.02	0.7	-0.01
	5 - 10	52886	-0.01	14.7	1.24	-0.02	0.20	0.052	1.92	14.7	12.2	1.48	0.03	1.4	-0.01
	10 - 15	52887	-0.01	15.4	0.69	0.02	0.23	0.027	0.90	28.2	10.7	1.27	0.01	2.3	0.09
	15 - 17	52888	-0.01	19.0	0.74	-0.02	0.30	0.045	1.74	16.6	5.43	2.89	0.01	2.1	0.04
	17 - 19	52889	-0.01	18.6	1.49	-0.02	-0.20	0.020	-0.01	43.5	7.06	3.30	0.04	9.6	0.47
	19 - 21	52890	-0.01	18.6	1.24	0.03	0.33	0.061	3.88	60.0	12.3	4.72	0.06	9.7	0.65
	21 - 26	52891	-0.01	18.3	1.74	-0.02	-0.20	0.028	1.57	17.8	3.70	1.49	0.02	1.0	-0.01
	26 - 28	52892	-0.01	19.7	0.99	-0.02	0.22	0.095	-0.01	56.0	5.51	6.16	0.06	18.6	1.33
	28 - 32	52893	-0.01	21.5	0.69	-0.02	-0.20	0.011	1.33	10.0	1.96	1.77	0.01	1.2	-0.01
	32 - 35	52894	0.22	67.5	0.54	-0.02	-0.20	0.041	1.31	71.0	8.50	3.27	0.03	4.4	0.17
	35 - 45	52895	0.22	21.1	0.84	-0.02	0.57	0.048	2.54	121.0	14.3	7.84	0.04	10.2	2.15
	45 - 55	52896	0.17	17.9	0.84	-0.02	0.60	0.058	2.48	66.0	4.76	4.57	0.04	5.1	1.65
	55 - 65	52897	0.11	22.9	1.49	-0.02	0.25	0.020	2.70	49.7	2.06	2.45	0.03	4.2	1.23
	65 - 75	52898	0.11	18.3	1.24	0.02	0.34	0.007	3.13	61.0	3.40	4.49	0.04	5.3	1.41
	75 - 85	52899	0.06	20.4	1.29	-0.02	0.32	0.032	4.76	68.0	5.67	5.65	0.04	4.7	1.57
	85 - 92	52900	0.11	31.5	1.84	-0.02	0.20	0.306	6.46	68.0	8.96	10.1	0.08	5.2	5.65
	I.B. 117 - 127	52901	0.33	21.1	1.14	0.02	0.20	0.105	28.1	50.0	1.50	5.50	0.06	9.3	1.53
	I.B. 127 - 137	52902	0.06	17.9	1.19	0.03	0.26	0.098	11.4	45.0	4.55	2.59	0.04	3.0	0.84
	I.B. 137 - 147	52903	0.06	18.3	0.50	-0.02	0.20	0.062	4.03	38.1	3.08	1.90	0.02	2.4	0.59
	I.B. 147 - 157	52904	0.17	16.1	1.14	-0.02	0.27	0.045	3.65	42.2	4.00	2.53	0.03	3.6	0.84
	I.B. 157 - 162	52905	0.17	19.7	2.13	0.02	0.38	0.045	3.59	63.0	5.16	4.65	0.04	4.8	1.37

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CONSULTING GEOTECHNICAL ENGINEERS
Great Falls, Billings, Montana - Boise, Idaho - Gillette, Wyoming

All In Parts Per Million
(-) Indicates Less Than Given Value

ANALYSIS OF TRACE ELEMENTS IN OVERBURDEN
AREA A, SECTION 32
WESTERN ENERGY COMPANY - COLSTRIP, MONTANA

January 19, 1976
Job No. 69-147

Sample Location	Depth, Ft.	Lab No.	Nitrate Nitrogen	Ammonia Nitrogen	Boron	Selenium	Molybdenum	Mercury	Zinc	Iron	Manganese	Copper	Cadmium	Lead	Nickel
54000N-	0 - 2	52927	0.44	24.7	1.29	-0.02	-0.20	0.032	8.35	12.9	4.54	0.98	0.03	0.6	0.14
47000E	2 - 6	52928	0.22	15.8	1.59	0.04	0.26	0.026	1.52	37.6	2.69	2.98	0.07	3.1	0.67
	6 - 8	52929	0.67	23.6	1.69	-0.02	-0.20	0.021	3.15	13.4	3.68	0.98	0.03	1.6	0.04
	8 - 11	52930	3.00	19.7	1.93	0.02	-0.20	0.028	1.19	26.2	7.80	1.18	0.03	3.3	0.06
	11 - 14	52931	2.61	15.4	1.29	0.03	-0.20	0.019	0.98	11.7	2.54	1.33	0.04	1.4	0.11
	14 - 17	52932	2.89	24.0	1.19	0.02	0.33	0.102	1.52	41.0	1.78	2.38	0.06	2.9	0.52
	17 - 19	52933	3.66	20.8	1.09	0.05	-0.20	0.036	0.66	18.2	5.05	0.82	0.01	1.2	-0.01
	19 - 21	52934	2.44	20.9	1.29	0.02	-0.20	0.009	0.60	6.5	1.50	0.98	-0.01	1.4	-0.01
	21 - 27	52935	1.11	17.2	1.04	0.02	0.20	0.016	3.41	61.6	12.6	0.77	-0.01	0.5	0.06
	27 - 31	52936	0.44	23.3	1.49	-0.02	0.22	0.024	2.33	31.3	4.31	3.09	0.03	6.1	0.82
	31 - 36	52937	0.33	32.9	2.18	-0.02	-0.20	0.042	1.18	52.2	1.38	8.08	0.03	6.8	1.62
	36 - 46	52938	0.33	38.3	1.88	0.02	0.98	0.050	5.88	48.8	6.79	5.37	0.04	5.2	2.47
	46 - 56	52939	0.39	44.4	1.84	0.03	0.82	0.051	5.22	50.0	7.28	2.38	0.04	6.4	2.76
	56 - 66	52940	0.22	30.1	1.29	-0.02	0.54	0.023	4.78	69.0	9.06	1.67	0.03	2.8	1.60
	66 - 76	52941	0.44	26.9	6.99	-0.02	0.43	0.021	3.20	85.0	6.37	2.51	0.04	7.5	2.44
	76 - 86	52942	0.50	21.8	1.84	0.02	0.58	0.033	2.85	52.0	5.22	3.16	-0.01	8.4	1.10
	86 - 96	52943	0.28	23.3	1.29	-0.02	0.27	0.031	1.72	67.0	5.86	2.23	-0.01	15.5	0.60
	96 - 106	52944	0.28	25.4	1.29	0.02	0.61	0.021	3.42	64.0	8.52	1.54	0.01	5.9	1.11
	106 - 116	52945	0.22	24.0	2.03	0.04	0.39	0.037	1.64	102.0	15.7	2.90	-0.01	3.6	0.59
	116 - 126	52946	0.22	26.9	1.34	0.04	0.47	0.060	2.80	62.0	9.69	2.09	-0.01	2.6	1.04
	126 - 136	52947	0.33	25.1	1.19	0.02	0.71	0.087	2.23	90.0	15.9	2.30	-0.01	5.7	1.47
	136 - 146	52948	0.28	19.7	0.50	-0.02	0.37	0.036	2.51	63.0	8.01	1.41	-0.01	3.2	1.13
	146 - 156	52949	0.50	22.9	1.64	0.02	0.89	0.045	5.52	69.0	10.6	3.89	0.04	11.1	2.52
	156 - 159	52950	0.50	31.5	11.9	0.04	0.27	0.108	5.37	92.0	16.9	6.44	0.23	4.9	2.03
1.B.	183 - 190	52951	0.44	24.7	2.88	0.02	0.23	0.008	9.84	57.0	7.33	1.75	0.02	6.3	1.10
1.B.	190 - 200	52952	0.39	18.6	1.54	-0.02	0.28	0.030	5.68	82.0	5.56	1.79	0.01	3.9	0.30
1.B.	200 - 210	52953	0.28	19.0	1.34	0.03	0.21	0.012	4.48	22.7	1.87	1.47	-0.01	1.9	0.33
1.B.	210 - 220	52954	0.22	17.9	1.39	-0.02	0.27	0.010	2.57	20.4	2.15	1.00	-0.01	1.8	0.43
1.B.	220 - 230	52955	0.17	17.9	1.49	-0.02	0.25	0.012	8.23	21.8	2.64	0.78	-0.01	1.7	0.35

NORTHERN TESTING LABORATORIES, INC.
CONSULTING GEOTECHNICAL ENGINEERS
Great Falls, Billings, Montana - Boise, Idaho - Gillette, Wyoming

CHEMICAL ANALYSIS OF TOPSOIL AND OVERBURDEN
AREA A SECTION 32
55000N 48000E
WESTERN ENERGY COMPANY - COLSTRIP, MONTANA

January 19, 1976
Job No. 69-147

Depth, Feet	Lab No.	pH	Conductivity mmhos/cm	Saturation %	Calcium meq/Liter	Calcium meq/100 grams*	Magnesium meq/Liter	Magnesium meq/100 grams*	Sodium meq/Liter	Sodium meq/100 grams*	SAR	Texture**	Probable Subsurface Formation
0 - 6	52906	8.0	0.65	36.0	0.87	0.03	1.06	0.04	6.17	0.22	6.28	Sandy Clay Loam	Dk. Brown Topsoil
6 - 13	52907	8.2	8.75	32.0	22.4	0.72	37.5	1.20	67.2	2.15	12.28	Sandy Loam	Dk. Brown Clay
13 - 17	52908	8.2	8.00	34.7	22.7	0.79	33.3	1.16	62.0	2.15	11.72	Loam	Brown Sandy Shale
17 - 24	52909	7.9	5.30	33.7	8.36	0.28	21.0	0.71	42.4	1.43	11.07	Loam	Brown Sandy Shale
24 - 29	52910	7.5	4.30	44.4	9.48	0.42	18.2	0.81	31.8	1.41	8.55	Silty Clay Loam	Gray Shale
29 - 32	52911	8.2	3.10	37.7	4.03	0.15	5.99	0.23	28.8	1.09	12.87	Silt Loam	Brown Shale
32 - 35	52912	8.1	3.20	53.4	3.59	0.19	9.59	0.51	26.1	1.39	10.17	Clay	Gray Shale
35 - 42	52913	8.2	2.60	30.7	2.99	0.09	5.51	0.17	23.2	0.71	11.25	Loam	Brown Sandy Shale
42 - 45	52914	8.1	3.40	34.2	3.84	0.13	8.99	0.31	26.7	0.91	10.54	Silt Loam	Dk. Brown Shale
45 - 47	52915	7.9	2.70	32.0	3.24	0.10	4.95	0.16	21.8	0.70	10.77	Sandy Clay Loam	Gray Sandstone
47 - 51	52916	8.1	2.80	60.9	2.50	0.15	5.45	0.3[illegible]	23.7	1.44	11.89	Clay	Gray Shale
51 - 55	52917	8.3	3.10	35.1	2.43	0.09	3.25	0.11	29.7	1.04	17.62	Silt Loam	Brown Shale
55 - 57	52918	7.3	4.60	54.8	12.1	0.66	14.1	0.77	35.2	1.93	9.73	Silty Clay	Gray Shale
57 - 64	52919	8.4	3.80	28.6	2.69	0.08	2.64	0.08	41.0	1.17	25.11	Loam	Brown Sandy Shale
64 - 74	52920	7.9	3.50	42.5	2.45	0.11	2.35	0.10	36.0	1.53	23.14	Silty Clay Loam	Gray Shale
105 - 110 I.B.	52921	7.4	2.85	45.5	3.05	0.14	2.07	0.09	27.8	1.26	17.38	Silty Clay	Dk. Gray Shale
110 - 120 I.B.	52922	7.1	3.60	34.4	8.94	0.31	6.67	0.23	31.1	1.07	11.13	Silt Loam	Dk. Gray Shale
120 - 130 I.B.	52923	7.5	3.70	31.7	7.00	0.22	5.48	0.17	31.9	1.01	12.77	Loam	Dk. Gray Sandy Shale
130 - 140 I.B.	52924	7.8	2.00	26.9	4.58	0.12	3.15	0.08	14.4	0.39	7.32	Sandy Loam	Gray Sandstone
140 - 150 I.B.	52925	7.5	1.35	26.9	3.58	0.10	3.35	0.09	7.75	0.21	4.16	Sandy Loam	Gray Sandstone
150 - 160 I.B.	52926	7.3	1.60	30.0	3.64	0.11	3.30	0.10	10.3	0.31	5.53	Sandy Loam	Gray Sandstone

*Oven Dry Soil
**U. S. Department of Agriculture Soil Textural Triangle

NORTHERN TESTING LABORATORIES, INC.
CONSULTING GEOTECHNICAL ENGINEERS
Great Falls, Billings, Montana - Boise, Idaho - Gillette, Wyoming

January 19, 1976
Job No. 69-147

ANALYSIS OF TRACE ELEMENTS IN OVERBURDEN
AREA A, SECTION 32
WESTERN ENERGY COMPANY - COLSTRIP, MONTANA

All In Parts Per Million (-) Indicates Less Than Given Value

[illegible]	Depth, Ft.	Lab No.	Nitrate Nitrogen	Ammonia Nitrogen	Boron	Selenium	Molybdenum	Mercury	Zinc	Iron	Manganese	Copper	Cadmium	Lead	Nickel
CON-	0 - 8	52906	0.44	18.6	1.74	-0.02	-0.20	0.027	2.58	9.3	9.54	2.57	0.04	1.3	0.33
CCE	8 - 13	52907	0.17	19.3	1.54	-0.02	0.49	0.028	2.60	16.6	33.1	4.35	0.03	0.9	0.19
	13 - 17	52908	0.11	22.6	1.19	0.02	0.21	0.057	1.96	11.6	19.0	3.04	0.03	1.3	0.22
	17 - 24	52909	0.11	23.6	0.89	-0.02	0.33	0.055	1.34	7.8	5.46	2.11	0.02	0.9	0.08
	24 - 29	52910	0.17	20.8	1.29	-0.02	0.58	0.087	1.93	55.0	5.98	2.36	0.05	6.0	1.00
	29 - 32	52911	0.06	21.8	0.60	-0.02	-0.20	0.041	2.51	8.9	3.98	4.34	0.02	0.9	0.06
	32 - 35	52912	0.17	27.9	1.19	0.03	0.21	0.078	2.79	53.3	4.24	2.97	0.05	11.9	1.17
	35 - 42	52913	0.06	19.7	1.54	-0.02	-0.20	0.028	0.63	25.5	5.75	0.65	0.02	1.2	0.10
	42 - 45	52914	0.11	22.2	1.49	-0.02	0.42	0.058	2.25	40.6	7.63	1.64	0.03	2.4	0.35
	45 - 47	52915	0.11	26.9	2.03	-0.02	0.26	0.036	3.26	73.0	6.91	1.61	0.02	4.6	0.73
	47 - 51	52916	0.22	25.4	1.34	-0.02	0.52	0.071	-0.01	87.0	10.0	3.13	0.04	5.2	1.75
	51 - 55	52917	0.11	24.7	0.74	-0.02	0.20	0.013	2.25	21.8	4.30	3.40	0.03	3.4	0.17
	55 - 57	52918	0.28	25.4	1.29	0.02	0.49	0.150	2.80	72.0	16.4	3.47	0.05	8.2	1.80
	57 - 64	52919	0.28	20.4	0.84	-0.02	0.48	0.038	2.00	19.6	6.60	2.55	0.02	0.5	0.04
	64 - 74	52920	0.28	21.1	1.14	-0.02	0.46	0.055	3.07	76.0	12.3	2.73	0.05	5.6	1.41
I.B.	105 - 110	52921	0.44	26.9	4.12	-0.02	2.50	0.180	9.14	30.1	3.40	3.06	0.05	10.3	0.87
I.B.	110 - 120	52922	0.67	23.6	1.64	0.03	0.47	0.089	3.45	70.0	5.62	1.69	0.05	4.7	1.24
I.B.	120 - 130	52923	0.22	24.3	1.59	0.03	0.46	0.055	9.50	65.0	7.60	1.49	0.03	4.4	0.87
I.B.	130 - 140	52924	0.11	27.6	0.79	-0.02	0.24	0.025	2.00	22.4	2.50	0.83	0.02	1.9	0.47
I.B.	140 - 150	52925	0.17	26.1	0.89	-0.02	0.23	0.024	4.92	35.3	3.26	2.01	0.02	3.3	0.75
I.B.	150 - 160	52926	0.22	20.4	1.64	0.02	0.20	0.059	3.75	31.9	3.52	1.73	0.03	3.1	0.49

STATE

OVERBURDEN AND INTERBURDEN
ANALYSIS
for
AREA E-2

as required by

THE STRIP MINE COAL CONSERVATION ACT

and

PURSUANT RULES AND REGULATIONS

Chapter 220

Session Laws of Montana, 1973

Prepared by

MONTANA TESTING LABORATORIES, INC.

for

WESTERN ENERGY COAL COMPANY

Raymond T. Choriki Soils Specialist

1/74

PROJECT TITLE: OVERBURDEN AND INTERBURDEN ANALYSIS AS RELATED TO REVEGETATION PURPOSES IN COLSTRIP, MONTANA

JUSTIFICATION:

Revegetation can be a problem from soils containing some undesirable characteristics such as high sodium (SAR), high salt, high percentage of clay, structure that causes very little intake, and low fertility. This analysis was conducted to evaluate the potential problem that may occur from overburden and interburden material during strip mining operations. This was conducted to evaluate the problems that may exist prior to mining operations above the Rosebud and between the McKay and Rosebud coal seams.

METHODS AND MATERIALS:

1. Sample Collection

Six sets of drill core samples for Area E-2 were submitted by Western Energy Coal Company; N48 E64, N49 E64, N47 E65, N50 E62.5, N46 E66.5, N52 E62, N47,850 E59,150, N49,600 E59,100, and N51,300 E60,200. These were taken at various intervals depending upon the texture and color.

2. Sample Preparation

Samples were air dried and split in half. The first half will be kept in the plastic bag. The second half was prepared for analysis as follows:

1. 500 grams screened for mechanical analysis (9 mesh).
2. Screen 12 mesh and split samples - ½ for green house study
   ½ for lab analysis
3. Sample for laboratory analysis screened to 20 mesh size and kept for analysis. Sample for green house can be used for weathering also if desired. Because large quantities of samples are required for SAR and mechanical analysis, it may be necessary to analyze SAR and use the same sample for mechanical analysis.
4. 100 grams was sent to U. S. Testing Lab for trace elements.

5. Mechanicalanalysis screen size 9 mesh.

3. Chemical Analysis

1. pH and conductivity - saturated paste.
2. Sodium Adsorption Ratio.
3. Sodium Exchange Potential (calculate if necessary- need CEC also). This has the same interpretation values as SAR.
4. Micro Analysis

   Copper

   Iron (chelatable DPTA)

   Manganese

   Zinc

   Exchangeable Ammonium

   Nitrate

   Cadmium'

   Lead

   Mercury

   Selenium

   Molybdenum

   Boron

   Nickel
5. CEC
6. Mechanical Analysis
7. Plant Growth Test (if deemed necessary)
   - a) 500 grams of air dried soil or less if soil not available.
   - b) Add 50 ppm P as concentrated super phosphate.
   - c) Add 50 ppm N as NH_4NO_3 on weekly basis.
   - d) Seeded to Horsford barley 6 seeds/pot.
   - e) Water with distilled water to .33 bar or field capacity and maintain weight daily , and harvest(dry weight,tillers & stand).

RESULTS AND DISCUSSION:

Description of Soil as Submitted by Western Energy

Hole # N48 E64 Area E-2

Lab No.	Depth in Feet	Soil Description
7094	0-10	Light brown sandstone, fine grained
7095	10-20	Light brown sandstone, fine grained
7096	20-30	Light brown sandstone, fine grained
7097	30-40	Light brown sandstone, fine grained
7098	40-43	Light brown sandstone, fine grained
7099	43-53	Gray sand stone, fine grained
7100	53-63	Gray sandstone, fine grained
	63-88	Coal
7101	88-98	Gray shale, fine grained
7102	53-102	Gray shale, fine grained
Hole #49 E64 Area E-2		
7117	0-10	Light brown sand, fine grained
7118	10-20	Light brown sand, fine grained
7119	20-30	Light brown sand, fine grained
7120	30-40	Light gray sand, fine grained
7121	40-45	Brown sand, fine grained
7122	45-55	Gray sand, fine texture
7123	55-65	Gray silt shale
7124	65-75	Gray silt shale
7125	75-85	Light gray silt shale, fine texture
7126	85-87	Light gray silt shale
	87-112	Rosebud Coal
7127	112-122	Gray silt shale
7128	122-124	Gray silt shale
	124+	McKay Coal

Hole # N47 E65 Area E-2

Lab No.	Depth in Feet	Soil Description
7129	0-10	Light brown top soil
7130	10-20	Light brown sand, fine grained
7131	20-30	Light brown sand, fine grained
7132	30-40	Light brown sand, fine grained
7133	40-46	Gray silt shale
7134	46-56	Gray silt shale
7135	56-65	Gray silt shale
	65-90	Coal
7136	90-100	Gray silt shale, hard
	100 +	Coal

Hole # N50 E62.5 Area E-2

7137	0-10	Light brown top soil
7138	10-20	Light brown soil
7139	20-30	Light brown sandstone, fine grained
7140	30-35	Light brown sandstone, fine grained
7141	35-45	Light gray silt, fine texture
7142	45-55	Light gray silt shale
7143	55-62	Light gray silt shale
7144	62-87	Coal
7144	87-97	Dark gray silt shale
7145	97-100	Dark gray silt shale
	100 +	Dark gray silt shale

Hole # N52 E62 Area E-2

Lab No.	Depth in Feet	Soil Description
7146	0-10	Light brown top soil, very fine grain
7147	10-20	Light brown sand, very fine grain
7148	20-30	Light brown sand, coarse grain
7149	30-40	Light brown soft sandstone
7150	40-42	Light grayish brown sandstone, fine texture
7151	42-52	Light gray silt shale, hard
7152	52-62	Light gray silt shale, hard
7153	62-72	Light gray silt shale, very hard
7154	72-80	Light gray sand, mixed
	80-106	Coal
7155	106-116	Light gray silt shale
7156	116-126	Gray silt shale
	126 +	Coal

Hole # N46 E66 Area E-2

Lab No.	Depth in Feet	Soil Description
7157	0-10	Light brown sand, fine grained
7158	10-20	Brown sandstone, very fine grained
7159	20-30	Brown sandstone, very fine grained
7160	30-38	Brown sandstone, very fine grained
7161	38-44	Brown sandstone, very fine grained
7162	44-54	Gray silt shale
7163	54-64	Gray silt shale
7164	64-74	Gray silt shale, hard
7165	74-78	Gray silt shale, hard
	78-105	Coal
7166	105-115	Gray silt shale, hard
7167	115-118	Gray silt shale, hard
	118 +	Coal

Description of Soil as Submitted by Western Energy

Hole # N47,850 E59,150

Lab No.	Depth in Feet	Soil Description
8184	0-5	Light brown clay loam, top soil
8185	5-10	Light gray-brown clay loam, top soil
8186	10-15	Light grayish brown clay loam
8187	15-20	Light grayish brown clay loam
8188	20-25	Light brown sandstone, fine grained
8189	25-30	Light reddish brown sandstone, fine grained
8190	30-35	Light grayish brown sandstone, fine grained
8191	35-40	Gray sand stone, coarse
8192	40-45	Gray silt stone shale
8193	45-50	Dark gray silt stone shale
8194	50-55	Gray silt stone shale
8195	55-60	Gray silt stone shale
	60-84	
8196	84-90	Gray clay, intermittant coal
8197	90-95	Light gray clay, some coal
8198	95-100	Light gray clay
8199	100-105	Gray clay mixed with coal
8200	105-110	Gray clay mixed with coal

Hole # N49,600 E59,100

8201	0-5	Reddish brown fine sand, top soil
8202	5-10	Reddish brown sandstone, fine grained
8203	10-15	Grayish brown sandstone, fine grained
8204	15-20	Grayish brown sandstone, fine grained
8205	20-25	Grayish brown sandstone, fine grained
8206	25-30	Grayish brown sandstone, fine grained
8207	30-35	Grayish brown sandstone, fine grained
8208	35-40	Grayish brown sandstone, fine grained
8209	40-45	Grayish brown sandstone, fine grained
8210	45-50	Grayish brown sandstone
8211	50-55	Gray-brown silty shale
8212	55-60	Gray-brown silty shale
8213	60-65	Gray-brown silty shale
8214	65-70	Reddish gray silty shale
8215	70-75	Reddish gray silty shale
8216	75-80	Reddish gray silty shale
8217	80-82	Reddish gray silty shale mixed with coal
Coal	82-105	
8218	105-110	Gray sandstone, fine grained, with coal present
8219	110-115	Light gray sandstone with coal present
8220	115-120	Light gray sandstone with coal present
8221	120-125	Light gray sandstone with coal present

Hole # N51,300 E60,200

Lab No.	Depth in Feet	Soil Description
8222	0-5	Very fine reddish gray sand, top soil
8223	5-10	Reddish soil with gray clay, top soil
8224	10-15	Light reddish clay
8225	15-20	Soft grayish brown sandstone, fine grained
8226	20-25	Soft grayish brown sandstone, fine grained
8227	25-30	Soft grayish brown sandstone, fine grained
8228	30-35	Soft light brown sandstone, fine grained
8229	35-40	Soft reddish brown sandstone, fine grained
8230	40-45	Gray silty stone shale
8231	45-50	Gray silty stone shale
8232	50-55	Grayish red , very fine sand
8233	55-60	Light grayish-red sandstone, very fine grained
8234	60-65	Light grayish brown sandstone, very fine grained
8235	65-70	Gray silty clay
8236	70-75	Gray silty clay
8237	75-80	Gray silty clay
8238	80-85	Gray silty clay
Coal	85-111	
8239	111-115	Gray silt stone with coal mixed
8240	115-120	Gray silty stone with coal mixed
8241	120-125	Gray silt stone shale
8342	125-130	Gray silt stone shale
8243	130-132	Gray silt stone shale
Coal	132-164	
8244	164-169	Hard gray silt stone shale
8245	169-174	Hard gray silt stone shale

Hole # N48 E64 (Tables 1, 2 & 3)

pH is a measure of hydrogen ion activity. Most Montana soils have a pH between 6 and 8.2. pH less than 6 will increase solubility of some metals and present a nutrient imbalance while soil above 8.2 may indicate high soluble carbonates, low solubility of calcium and magnesium salts, and high sodium.

pH exceeded 8.2 on 30-40' increment. Sodium Adsorption Ratio values were very low however at that depth. Should not cause any sodium related problems.

Electrical Conductivity was very low and should not restrict plant growth.

Sodium Adsorption Ratio was well below 10-12 values and should have no problem on structural stability and permeability.

Textural clalles of the area are sandy clay loam, sandy loam, 19am and clay loam. Clay content is between 12 to 28% on all increments taken (0-102') and should maintain desirable texture for plant growth.

Nitrogen as nitrate was very low on all samples. Exchangeable ammonium was present with 10-15 ppm at various depths. Since ammonium ions can be converted to nitrate with appropriate soil bacteria, it can be a threat to underground water tables or surface run off with streams, if not properly used by plants. Nitrogen requirement for grass establishment should be adjusted during year of establishment.

Nitrification of Exchangeable Ammonium in soil buried at lower depths should be very slow because of sterile environment, and low oxygen and moisture; anticipate rapid conversion to nitrate near the surface. It is unlikely that exchangeable ammonium would leach readily because of its nature.

DTPA chelatable zinc, manganese, iron and copper were not extremely high. Layer immediately above the coal seems to have a higher level (4.5 ppm) of chelatable copper.

Hot water extractable Selenium was well below 1.0 ppm at all depths and should not restrict growth.

Mercury (acid extractable) was well below 500 ppb level. The layer immediately above the Rosebud coal was unusually higher than the remaining layers with 240 ppb. It is doubtful that this would restrict plant growth and development.

Boron, cadmium and molybdenum are well below levels of anticipated problems and should not restrict plant growth.

Nickel above and below the coal seam was above 1.0 ppm but should not restrict plant growth.

Lead exceeded 5 ppm near the coal seam and should not be permitted to be placed near the surface.

SUMMARY

1. Lead exceeded 5 ppm above the coal seam and requires special handling of soil.
2. Soluble salts were very low and anticipate very little problem or none on all other depths.

Table ___ Chemical Properties of Soil and Overburden Materials Associated with Coal Areas. Western Energy Coal Company. Area E-2

Hole # N48 E64

					Saturated Extract			
					Cations			
Lab No.	Depth feet	pH Paste	Sat'n. %	Elect. Cond. mmhos/cm.	Ca	Mg	Na	SAR
					meq/liter			
7094	0-10	8.0	23.2	0.33	3.9	1.6	2.8	1.72
7095	10-20	8.2	30.3	0.5	3.9	3.3	3.6	2.05
7096	20-30	8.1	24.5	0.33	3.6	3.9	4.4	2.25
7097	30-40	8.4	26.3	0.3	2.1	1.4	2.4	1.81
7098	40-43	8.1	25.8	0.43	4.8	5.3	3.0	1.34
7099	43-53	8.2	26.0	0.73	5.2	6.2	4.3	1.47
7100	53-63	7.8	40.5	0.8	7.5	7.1	2.9	1.09
Coal Seam	63-88							
7101	77-98	8.0	27.7	0.87	6.3	8.3	3.1	1.14
7102	98-102	7.7	28.5	2.3	10.8	11.9	3.5	1.03

Table ___ Results of Mechanical Analysis (Hydrometer Method) with Nitrates and Micro Nutrients (Zinc, Iron, Copper, and Manganese) for Overburden Samples. Western Energy Coal Company. Area E-2

Hole # N48 E64

Lab No.	Depth feet	% Clay	% Silt	% Sand	Texture	NO_3	Zn	Fe	Cu	Mn
7094	0-10	18.2	14.3	67.5	SL	0.50	1.4	4.6	1.2	2.0
7095	10-20	24.4	22.0	53.6	SCL	0.50	0.2	4.4	1.4	1.8
7096	20-30	14.6	19.6	65.8	SL	3.75	1.1	6.3	1.4	2.8
7097	30-40	12.0	10.4	77.6	SL	2.50	0.2	3.9	1.4	2.8
7098	40-43	21.2	24.6	54.2	SCL	0.25	17.5	16.6	1.8	7.6
7099	43-53	12.6	13.6	73.8	SL	0.50	2.9	18.4	2.0	4.0
7100	53-63	28.4	38.8	32.8	CL	1.25	13.8	22.9	4.5	4.8
Coal Seam	63-88									
7101	83-98	22.0	36.4	41.6	L	0.25	3.2	7.2	2.3	4.0
7102	98-102	15.6	40.0	44.4	L	0.25	16.0	9.8	2.4	4.8

Table ___ Chemical Analysis of Overburden Samples. Western Energy . Area E-2.

Hole # N48 E64

Lab No.	Depth feet	Ex.NH_4 (ppm)	Se (ppm)	Hg (ppb)	B (ppm)	Pb (ppm)	Cd (ppm)	Ni (ppm)	Mo (ppm)	CEC meq/100gr
7094	0-10	10.0	<0.5	10.0	0.2	0.8	0.1	0.2	0.07	5.0
7095	10-20	11.0	<0.5	40.0	0.4	1.0	0.1	0.2	0.06	5.3
7096	20-30	11.0	<0.5	10.0	0.4	0.9	0.1	0.2	0.04	3.5
7097	30-40	12.0	<0.5	40.0	0.3	0.8	0.1	<0.1	0.03	2.5
7098	40-43	12.0	<0.5	10.0	0.5	2.2	0.1	0.4	0.03	3.5
7099	43-53	12.0	<0.5	40.0	0.5	2.3	0.1	0.6	0.06	2.0
7100	53-63	13.0	<0.5	240.0	1.3	6.4	0.2	1.9	0.09	7.5
Coal Seam	63-88									
7101	88-98	13.0	<0.5	40.0	0.7	4.2	0.2	1.1	0.11	2.7
7102	98-102	15.0	<0.5	80.0	1.1	2.3	0.2	0.8	0.11	3.1

HOLE # N49 E64 (Table 4,5,6)

pH is between 6 and 8.2 on all depths except 10-30' and 40-45'. These depths contain hgiher pH but should not limit plant growth if sodium is low and fertilizer supplemented.

Soluble salts are well below expected level of anticipated problems. Soluble salts were 1.53 mmhos/cm and lower throughout the depth. This should not restrict plant growth and development.

Sodium Adsorption Ratio is very low and should not cause any soil related problem.

Textural classes of the area are sandy loam, loamy sand, loam, sandy clay loam and silty clay loam. Texture remains favorable and may help leach the salt from the shale to a lower depth. At 85-87' the fine material accummulated and should not be allowed to be left on the surface.

Nitrate Nitrogen is very low. Exchangeable ammonium is repeatedly high (above 10 ppm). This should help relieve the need of nitrogen in later years as this becomes available.

Chelatable Zinc, Manganese, Iron and Copper are well below expected toxic levels. The copper above the Rosebud layer is higher than the normal level found in soil.

Selenium is very low (less than .5 ppm) and should not restrict any plant growth.

Mercury (Hg) is low and should not restrict plant growth.

Boron is well below 3 ppm and should not restrict plant growth.

Molybdenum is low and should not restrict plant growth.

Cadmium is low and should not restrict plant growth.

Nickel exceed 1.0 ppm between 45-124 feet. At least this is a suggested level that may cause some problems and should be kept at lower depth. It seems to be higher, above and below the coal layer.

Lead exceed 5.00 ppm between 65-75 feet, 85-87 feet, and 112-122 feet. This may cause some problem in plant growth and development.

SUMMARY

1. Nickel exceeded 1.0 ppm between 45-124 feet and may restrict normal plant growth.development.

2. Lead exceeds 5.0 ppm between 65-75', 85-87', and 112-122' and may restrict normal plant growth and development.

3. Anticipate no problem in relation to texture to soil physical problem, as texture, crusting, low permeability, or other chemically related problems.

Table [illegible] Chemical Properties of Soil and Overburden Materials Associated with Coal Areas. Western Energy Coal Company. Area E-2

Hole # N49 E64

Lab No.	Depth feet	pH Paste	Sat'n. %	Elect. Cond. mmhos/cm.	Saturation Extract Cations Ca (meq/liter)	Mg (meq/liter)	Na (meq/liter)	SAR
7117	0-10	8.1	28.9	0.2	1.1	3.1	3.4	2.32
7118	10-20	8.6	26.0	0.97	6.3	8.7	4.9	1.79
7119	20-30	8.3	32.6	1.33	8.0	10.1	3.0	3.01
7120	30-40	8.0	26.5	1.3	10.4	9.3	4.9	1.56
7121	40-45	8.3	25.0	0.47	2.2	5.0	2.5	1.33
7122	45-55	8.1	29.8	0.2	6.0	7.2	2.2	2.45
7123	55-65	8.1	31.6	1.1	3.9	5.6	2.3	1.05
7124	65-75	8.1	31.3	0.83	4.8	7.1	3.6	1.43
7125	75-85	8.0	26.7	1.53	9.4	11.7	5.6	1.08
7126	85-87	7.9	59.4	1.5	10.1	11.2	5.4	1.67
Coal Seam	87-112							
7127	112-122	8.0	32.9	1.17	5.0	4.2	7.8	3.65
7128	122-124	8.0	31.8	1.7	8.5	6.3	11.7	4.30

Table 5 Results of Mechanical Analysis (Hydrometer Method) with Nitrates and Micro Nutrients (Zinc, Iron, Copper, and Manganese) for Overburden Samples. Western Energy Coal Company. Area E-2

Lab No.	Depth feet	% Clay	% Silt	% Sand	Texture	NO_3	Zn	Fe	Cu	Mn
7117	0-10	10.8	7.4	81.8	SL	0.25	3.0	3.0	1.6	2.4
7118	10-20	10.4	6.6	83.0	LS	0.25	3.2	1.4	2.0	2.0
7119	20-30	7.2	6.4	86.4	LS	0.25	13.0	2.4	0.9	3.2
7120	30-40	12.4	13.0	74.6	SL	0.25	2.5	2.0	1.4	2.8
7121	40-45	10.0	13.0	77.0	SL	0.25	16.0	3.8	1.4	5.8
7122	45-55	15.2	36.8	48.0	L	0.25	3.9	30.0	2.0	7.0
7123	55-65	22.4	27.2	50.4	SCL	0.25	4.3	50.0	1.4	7.4
7124	65-75	20.4	32.0	47.6	L	0.25	2.5	95.0	1.8	9.2
7125	75-85	16.8	31.6	51.6	L	0.25	9.0	22.9	1.6	4.0
7126	85-87	48.8	32.6	18.6	SiCL	0.25	7.5	30.0	5.6	3.2
Coal Seam	87-112									
7127	112-122	26.0	25.6	48.4	SCL	0.25	14.5	8.4	2.6	3.4
7128	122-124	18.0	27.6	54.4	SL	0.25	16.8	9.3	2.4	4.4

Table 6 Chemical Analysis of Overburden Samples. Western Energy. Area E-2.

Hole # N49 E64

Lab No.	Depth feet	Ex.NH$_4$ (ppm)	Se (ppm)	Hg (ppb)	B (ppm)	Pb (ppm)	Cd (ppm)	Ni (ppm)	Mo (ppm)	CEC meq/100gr
7117	0-10	24.0	0.5	6.0	0.2	1.3	0.2	0.1	1.2	16.5
7118	10-20	20.0	0.5	6.0	0.5	1.3	0.1	0.1	0.11	5.0
7119	20-30	17.0	0.5	10.0	0.1	1.4	0.1	0.1	0.07	19.0
7120	30-40	15.0	0.5	6.0	0.2	1.9	0.1	0.2	0.1	2.7
7121	40-45	21.0	0.5	6.0	0.2	2.1	0.2	0.3	0.18	23.0
7122	45-55	36.0	0.6	16.0	0.3	4.0	0.2	1.2	0.36	2.7
7123	55-65	45.0	0.5	20.0	0.3	4.8	0.2	1.6	0.40	2.7
7124	65-75	45.0	0.5	16.0	0.4	5.7	0.2	1.9	0.39	2.7
7125	75-85	24.0	0.5	30.0	0.6	4.1	0.2	1.6	0.26	2.0
7126	85-87	30.0	0.5	82.0	2.0	5.1	0.2	1.8	0.26	2.0
Coal Seam	87-112									
7127	112-122	30.0	0.5	28.0	1.2	6.8	0.2	2.8	0.74	2.7
7128	122-124	29.0	0.5	140.0	0.8	3.3	0.2	1.4	0.65	1.7

HOLE # N47 E65 (Table 7, 8, & 9)

pH is unusually high on the upper 40 feet. This level may indicate high carbonate or sodium and supplemental fertilizer becomes important.

The Soluble Salts on surface 10' were moderately high and should not be permitted to be left on the surface.
The lower depth remain satisfactory, and should not restrict plant growth and establishment.

Sodium Adsorption Ratio is exceptionally high on the surface 10 feet. SAR values below 10' seem to be low in sodium in relation to calcium and magnesium.

Texture of this hole seems quite coarse (sandy loam and loamy sand). The salt and sodium should leach readily and prevent accumulation near the surface.

Nitrate Nitrogen is very low. Exchangeable ammonium was present throughout the hole and concentration varied from 8-32 PPM. This is a source of nitrogen and nitrogen requirement should be adjusted at seeding.
Chelatable Zinc, Manganese, Iron and Copper were below the anticipated level to decrease plant production. For some reason, the zinc content was quite a bit higher than normally found on the surface soil in the 0-10' increment.

Selenium was very low, below 1.0 ppm, and should not restrict growth.

Mercury was all below 40 ppb and well below expected toxicity level of 500 ppb.

Boron is low and should not restrict growth.

Lead DTPA chelatable lead between 1-5 should be looked at with suspicion. Depth between 46-60 contain 3.6 to 4.0 ppm lead.

Cadmium is well below expected toxicity level of 1.00 ppm.

Nickel exceeds toxic level at depths just below and just above the coal seam at depths of 56-65' and 90-100', and may restrict plant growth.

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Table ___ Chemical Properties of Soil and Overburden Materials Associated with Coal Areas. Western Energy Coal Company. Area E-2

Hole #N47 E65

Lab No.	Depth feet	pH Paste	Sat'n. %	Elect. Cond. mmhos/cm.	Saturated Extract Cations Ca	 Mg	 Na	SAR
					- - - - -	meq/liter	- - - - -	
7129	0-10	8.3	28.9	20.97	27.5	75.0	75.2	10.50
7130	10-20	8.5	23.0	13.43	16.5	25.0	18.0	3.95
7131	20-30	8.4	29.5	0.67	4.8	8.0	3.2	0.89
7132	30-40	8.4	30.9	0.5	8.3	10.8	2.5	0.82
7133	40-46	8.0	28.3	0.1	11.5	20.8	3.0	0.74
7134	46-56	8.1	29.7	1.9	10.8	8.9	3.2	1.01
7135	56-65	7.6	39.0	13.03	17.0	33.3	3.7	0.74
Coal Seam	65-90							
7136	90-100	7.7	36.3	2.23	15.0	8.7	5.3	1.54

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Table ___ Results of Mechanical Analysis (Hydrometer Method) with Nitrates and Micro Nutrients (Zinc, Iron, Copper, and Manganese) for Overburden Samples. Western Energy Coal Company. Area E-2.

Hole # N47 E65

Lab No.	Depth feet	% Clay	% Silt	% Sand	Texture	NO_3	Zn	Fe	Cu	Mn
7129	0-10	8.0	19.6	72.4	SL	0.25	52.6	4.6	1.6	7.0
7130	10-20	8.0	8.4	83.6	LS	0.25	6.0	4.6	1.1	3.6
7131	20-30	3.8	14.2	82.0	LS	0.25	4.3	6.0	1.1	3.6
7132	30-40	8.4	11.2	80.4	SL	0.25	0.9	2.0	1.2	3.4
7133	40-46	10.0	6.0	84.0	LS	0.25	1.6	6.6	1.4	4.8
7134	46-56	12.0	8.0	80.0	SL	0.25	7.5	15.8	2.0	6.4
7135	56-65	35.2	20.8	44.0	CL	0.25	19.0	19.0	2.3	5.8
Coal Seam	65-90									
7136	90-100	26.0	42.6	31.4	SiL	0.25	4.2	8.0	3.0	4.4

Table Chemical Analysis of Overburden Samples. Western Energy. Area E-2.

Hole # N47 E65

Lab No.	Depth	Ex. NH_4 (ppm)	Se (ppm)	Hg (ppb)	B (ppm)	Pb (ppm)	Cd (ppm)	Ni (ppm)	Mo (ppm)	CEC meq/100gr
7129	0-10	8.0	0.5	20.0	0.3	0.3	0.1	0.3	0.08	4.0
7130	10-20	32.0	0.5	20.0	0.3	1.1	0.1	0.3	0.08	2.6
7131	20-30	11.0	0.5	20.0	0.3	1.3	0.1	0.2	0.06	3.0
7132	30-40	11.0	0.5	10.0	0.3	1.5	0.1	0.3	0.07	2.5
7133	40-46	19.0	0.5	20.0	0.4	1.5	0.1	0.3	0.12	2.0
7134	46-56	15.0	0.5	25.0	0.5	3.6	0.1	0.8	0.13	1.9
7135	56-65	20.0	0.5	5.0	0.6	4.0	0.1	2.4	0.14	27.5
Coal Seam	65-90									
7136	90-100	23.0	0.5	40.0	0.9	6.1	0.1	1.8	2.1	3.8

Hole # M50 E62.5 (Tables 10, 11 & 12)

pH Values above 30 feet were 8.3, 8.5 and 8.4 respectively at 10' increments. These depths may cause fertility imbalance.

Soluble salts at 0-20' were moderately high (4-8 mmhos/cm) and may restrict normal plant growth. This depth should be placed below the surface.

SAR is low on all depths and should not restrict plant root development or permeability.

Textural classes are sandy loam, loamy sand, clay loam and silt loam. [illegible] are [illegible] desirable for permeability and should not restrict plant root development. The loamy sand will have very low water holding capacity. [illegible] leaching of salt is very possible in coarse textured soils, special handling is very important to prevent hard layer to develop at lower depths.

Nitrate nitrogen is very low. Exchangeable ammonium is high and should be a very good source of nitrogen.

DTPA chelatable zinc, manganese, iron and copper were analyzed and shown in Table [illegible]. Concentration of these values were below expected toxicity levels and should not restrict plant growth.

Selenium is below 1.0 ppm and should not restrict plant growth.

Mercury is well below expected toxicity level and should not restrict plant growth. Highest level was 90 ppb HG at 55-62' depth.

Boron is below toxicity level and should not restrict plant growth.

Lead exceeds the level of 5 ppm and may restrict or prevent normal growth. [illegible] lead levels were found at 35-55' and below the [illegible] (87-97'). These soils will be evaluated in the green house. Lead levels make it imperative that this depth be given special handling.

Cadmium is all below 0.1 ppm and below expected levels of toxicity.

Nickel toxicity level is 1.0 ppm, and several depths exceed this level. These depths are 56-65', 90-100', 35-62' and below the [illegible] coal seam (87-[illegible]'). These levels may restrict plant growth. Green house is recommended.

Molybdenum is all low and will not restrict plant growth.

SUMMARY

1. Soluble salts are moderately high at 0-20' and should be placed below the surface. Conductivity was 4.3 and 7.23 mmhos/cm at 0-10' and 10-20' respectively.
2. Lead exceeds 5 ppm at 35-55' and 87-97'. These depths may restrict normal plant development and should be properly placed well below the surface.
3. Nichel exceeded 1.0 ppm at 35-62' and 87-100'. These levels may restrict normal plant growth.

Table 10 Chemical Properties of Soil and Overburden Materials Associated with Coal Areas. Western Energy Coal Company. Area E-2.

Hole # N50 E62.5

Lab No.	Depth	pH	Sat'n.	Elect.	Saturated Extract			
					Cations			
		Paste		Cond.	Ca	Mg	Na	SAR
	feet		%	mmhos/cm.	- - - - - - meq/liter - - - - - -			
7137	0-10	8.3	27.6	4.30	18.8	103.3	7.0	0.99
7138	10-20	8.5	31.5	7.33	23.1	83.8	8.6	1.15
7139	20-30	8.4	28.0	2.53	4.5	24.2	10.0	2.69
7140	30-35	7.7	26.0	2.13	10.4	19.6	4.0	1.04
7141	35-45	7.8	31.5	0.93	6.0	12.9	4.6	1.50
7142	45-55	8.0	26.6	2.20	68.8	10.4	4.0	0.64
7143	55-62	8.1	27.4	2.00	10.8	15.0	3.8	1.07
Coal Seam	62-87							
7144	87-97	8.1	31.5	1.33	11.6	9.3	5.0	1.47
7145	97-100	7.8	26.3	2.00	9.1	8.7	6.3	2.11

Table 11 Results of Mechanical Analysis (Hydrometer Method) with Nitrates and Micro Nutrients (Zinc, Iron, Copper, and Manganese) for Overburden Samples. Western Energy Coal Company. Area E-2.

Hole # N50 E62.5

Lab No.	Depth feet	% Clay	% Silt	% Sand	Texture	NO_3	Zn	Fe	Cu	Mn
7137	0-10	18.0	16.0	66.0	SL	0.25	9.0	3.0	2.3	4.4
7138	10-20	14.8	13.0	72.2	SL	0.25	3.7	3.0	1.4	3.0
7139	20-30	14.4	7.6	78.0	SL	0.25	6.0	3.9	1.0	2.4
7140	30-35	10.8	12.8	76.4	SL	0.25	1.5	6.3	1.0	5.2
7141	35-45	26.2	28.4	45.4	L	0.25	20.6	30.0	2.0	7.4
7142	45-55	22.4	32.0	45.6	L	0.25	5.2	19.2	2.5	5.4
7143	55-62	25.4	23.0	51.6	SCL	0.25	21.4	19.2	2.2	4.4
Coal Seam	62-87									
7144	87-97	28.4	27.6	44.0	L	0.25	14.5	9.2	2.4	4.4
7145	97-100	21.2	13.2	65.5	SCL	0.25	12.2	11.2	1.8	4.2

Table 12 Chemical Analysis of Overburden Samples. Western Energy. Area E-2.

Hole # N50 E62.5

Lab No.	Depth Feet	Ex.Mn (ppm)	Se (ppm)	Hg (ppb)	B (ppm)	Pb (ppm)	Cd (ppm)	Ni (ppm)	Mo (ppm)	CEC meq/100gr
7137	0-10	8.0	0.5	5.0	0.6	1.3	0.1	0.2	0.13	6.0
7138	10-20	15.0	0.5	5.0	0.6	1.0	0.1	0.2	0.11	3.8
7139	20-30	7.0	0.5	5.0	0.3	0.9	0.1	0.1	0.13	3.1
7140	30-35	11.0	0.5	5.0	0.2	1.1	0.1	0.2	0.18	3.5
7141	35-45	45.0	0.5	40.0	0.3	5.5	0.1	1.9	0.29	3.7
7142	45-55	31.0	0.5	40.0	0.4	5.3	0.1	1.8	0.49	3.0
7143	55-62	30.0	0.5	90.0	0.6	4.6	0.1	1.8	0.45	8.0
Coal Seam	62-87									
7144	87-97	39.0	0.5	20.0	1.3	7.2	0.1	2.3	0.25	4.3
7145	97-100	29.0	0.5	5.0	1.3	4.7	0.1	1.6	0.80	3.5

Summary

1. Chelatable Zinc was low except at 40-42 feet with 44ppm. This layer may present some problem, but could be mixed with the layor above and below and should present no problem if mixed properly.

2. DPTA chelatable lead exceeded 5ppm between 62-72' and 116-126', and may restrict normal plant growth and development. This layer should be properly placed at lower depth.

3. DPTA chelatable nickel exceed 1;;m between 62-80' and 116-126' and the depth should not be permitted to be left on the surface. Would be preferable it should be mixed with layer inediately abover and below it and placed at lower depth.

4. All other analysis, both physical and shemical should not restrict plant growth and development.

Soluble salts were very low (less than 2.0mmhos/cm) and should not present a problem on seedling establichment, and plant growth and development.

Table 16 Chemical Properties of Soil and Overburden Materials Associated with Coal Areas. Western Energy Coal Company. Area E-2.

Hole # N46 E66.5

Lab No.	Depth	pH	Sat'n.	Elect. Cond.	Saturated Extract			
					Cations			
		Paste			Ca	Mg	Na	SAR
	feet		%	mmhos/cm.	- - - - - - - meq/liter - - - - - -			
7157	0-10	8.2	29.8	27.53	38.8	85.4	32.0	4.06
7158	10-20	8.4	29.3	13.83	16.5	41.7	20.5	4.83
7159	20-30	8.3	31.9	13.43	6.0	33.8	13.0	5.28
7160	30-38	8.2	30.0	2.5	7.5	29.2	9.0	2.05
7161	38-44	8.2	30.4	2.03	4.5	21.7	5.9	1.62
7162	44-54	8.0	30.9	1.67	4.0	17.5	4.7	1.43
7163	54-64	8.2	46.2	0.93	5.8	11.2	2.6	0.90
7164	64-74	7.8	41.1	1.03	5.2	9.7	2.2	0.81
7165	74-78	8.0	35.7	1.53	6.5	10.4	1.9	0.67
Coal Seam	78-105							
7166	105-115	7.9	37.9	2.1	8.8	10.4	6.2	2.01
7167	115-118	7.9	54.5	3.43	7.5	8.3	4.8	1.69

Table 17 Results of Mechanical Analysis (Hydrometer Method) with Nitrates and Micro Nutrients (Zinc, Iron, Copper, and Manganese) for Overburden Samples. Western Energy Coal Company. Area E-2.

Hole # N46 E66.5

Lab No.	Depth feet	% Clay	% Silt	% Sand	Texture	NO_3	Zn	Fe	Cu	Mn
7157	0-10	12.0	72.4	15.6	SiL	0.25	1.9	4.0	2.8	3.2
7153	10-20	22.8	24.8	52.4	SCL	0.25	1.5	7.2	2.5	3.2
7159	20-30	22.0	27.4	50.6	SCL	1.85	2.9	6.3	0.9	4.2
7160	30-33	21.6	26.0	52.4	SCL	1.25	3.5	4.4	1.1	4.2
7161	38-44	16.8	26.4	56.8	SL	0.50	13.2	6.3	1.4	3.6
7162	44-54	38.0	39.6	22.4	SiL	0.50	12.2	30.0	2.0	10.4
7163	54-64	47.6	35.6	16.8	SiC	0.50	11.3	65.0	2.0	11.1
7164	64-74	40.0	35.6	24.4	CL	0.50	5.2	30.0	1.8	9.2
7165	74-78	24.4	4.0	71.6	SCL	0.50	3.1	7.8	2.3	4.4
Coal Seam	73-105									
7166	105-115	21.2	25.5	53.3	SL	0.50	3.7	4.4	2.7	8.2
7167	115-118	44.8	24.0	31.2	C	0.50	9.4	22.9	7.2	10.0

Table 18 Chemical Analysis of Overburden Samples. Western Energy. Area E-2.

Hole # N46 E66.5

Lab No.	Depth feet	Ex.NH_4 (ppm)	Se (ppm)	Hg (ppb)	B (ppm)	Pb (ppm)	Cd (ppm)	Ni (ppm)	Mo (ppm)	CEC meq/100gr
7157	0-10	10.0	0.5	180.0	0.7	2.2	0.1	0.2	0.15	8.8
7158	10-20	16.0	0.5	40.0	0.6	1.8	0.1	0.1	0.10	4.3
7159	20-30	16.0	0.5	40.0	0.1	1.6	0.1	0.1	0.03	4.4
7160	30-38	16.0	0.5	40.0	0.1	1.5	0.1	0.1	0.03	4.4
7161	38-44	21.0	0.5	50.0	0.1	1.5	0.1	0.1	0.12	3.5
7162	44-54	44.0	0.5	60.0	0.1	6.1	0.1	1.8	0.28	4.4
7163	54-64	40.0	0.5	50.0	0.1	5.4	0.1	1.6	0.25	4.3
7164	64-74	48.0	0.5	50.0	0.3	4.9	0.1	1.5	0.26	3.8
7165	74-78	24.0	0.5	50.0	0.4	4.6	0.1	2.4	0.46	3.4
Coal Seam	78-105									
7166	105-115	25.0	0.5	40.0	0.6	4.9	0.1	1.2	0.12	2.7
7167	115-118	22.0	0.5	60.0	1.0	5.0	0.1	1.8	0.12	2.7

Hole # N47,850 E58,150 (Tables 19, 20 & 21)

Soluble salts are moderately high on the surface 25 feet, and should not be permitted to be left on the surface. Levels exceed 7.2 mmhos/cm. on the top 25 feet, but less than 2.93 mmhos/cm. from 25 feet and below.

SAR values are below 4.71 and should not present any problems.

Textural class is clay between 45 and 60 feet and should not be permitted to be used for top soil material. Depth beyween 30 and 45 feet appears favorable for top soil material based on soluble salts and textures. If the trace elements appear favorable it can be used for top soil if necessary.

Nitrate Nitrogen is very low, and should not accumulate and threaten underground water supply, runoff into rivers, or collect in stock water ponds.

Exchangeable ammonium varies with depth but are present throughout the hole. The exchangeable ammonium could be a threat to underground or runoff water if not properly used by plants. Because of the nitrogeni present some adjustment on the nitrogen application should be made, especially on the second year.

Selenium is very low and should not restrict plant growth.

Boron is very low and should not restrict plant growth from the toxicity aspect.

Lead is low on the top 40 feet but increases at 40 feet and below. If 5 ppm Pb is considered high, 45-60' and 84-95' should not be permitted for use for top soil material.

Nickel is low on the top 40 feet but exceeds 1.0 ppm at 40 feet and below. If 1.0 ppm is considered high, soil from these depths should not be permitted for use as top soil material.

Molybdenum is very low and should not restrict plant growth.

Hole # N47,850 E58,150 (continued)

Mercury is all very low. The highest value was 24 ppb Hg which should not restrict plant growth.

SUMMARY

1. Top 25 feet of soil exceeds 7.2 mmhos/cm. salt and should not be permitted for use as top soil material.

2. Depth at 40-60' contains clay, lead and nickel that may restrict plant growth and special handling of material should be advised.

3. Zinc appears high; 27, 50 and 11 ppm at 95-100', 100-105' and 105-110' respectively, and should not be permitted for use near surface.

4. Lead exceeded 4.4 ppm at 40-95' excluding the coal layer (60-84').

19C

Table 19 Chemical Properties of Soil and Overburden Materials Associated with Coal Areas.
Western Energy Area E-2

Hole # N47,850 E59,150

Lab No.	Depth	Paste	Sat'n.	Elect. Cond.	Saturation Extract Cations Ca	Mg	Na	SAR
	feet		%	mmhos/cm.	- - - - meq/liter - - - -			
8184	0-5	8.4	35.9	28.00	5.0	80.3	30.6	4.71
8185	5-10	8.3	31.7	28.17	7.0	75.6	24.5	3.83
8186	10-15	8.3	25.7	28.17	12.1	90.1	30.1	4.18
8187	15-20	8.3	32.6	26.50	4.8	55.1	22.9	2.97
8188	20-25	8.3	28.5	27.83	18.0	59.8	28.3	4.57
8189	25-30	8.3	31.2	2.93	4.7	16.8	9.8	2.98
8190	30-35	8.5	21.9	4.13	2.1	5.7	6.5	3.24
8191	35-40	8.2	26.9	3.00	2.5	5.2	1.6	0.80
8192	40-45	7.8	37.5	2.00	5.5	13.1	3.1	1.03
8193	45-50	7.9	42.7	3.60	6.3	9.2	3.3	1.18
8194	50-55	7.9	42.8	3.30	4.3	6.7	2.9	1.22
8195	55-60	8.0	43.0	4.30	4.3	6.1	3.0	1.30
Coal	60-84							
8196	84-90	7.8	36.6	3.90	6.0	8.4	2.6	0.97
8197	90-95	8.0	35.3	3.40	4.8	7.3	2.7	1.08
8198	95-100	7.9	31.6	3.50	6.0	7.1	3.2	1.22
8199	100-105	7.8	34.7	2.87	8.5	5.5	3.5	1.34
8200	105-110	7.9	33.5	2.87	11.3	10.8	3.1	0.94

Table 20 Results of Mechanical Analysis (Hydrometer Method) with Nitrates and Micro Nutrients (Zinc, Iron, Copper, and Manganese) for Overburden Samples. Western Energy Coal Company. Area E-2.

Hole #N47,850 E59,150

Lab No.	Depth feet	% Clay	% Silt	% Sand	Texture	NO_3	Zn	Fe	Cu	Mn
8184	0-5	10.2	36.4	53.4	SL	0.25	0.8	6.0	1.8	1.4
8185	5-10	1.6	59.4	39.0	SiL	0.25	0.3	4.4	2.4	1.2
8186	10-15	6.0	78.8	15.2	SiL	0.50	0.6	4.6	5.0	1.4
8187	15-20	2.6	35.8	61.6	SL	0.50	0.9	5.8	1.8	1.4
8188	20-25	16.2	26.0	57.8	SL	0.50	6.0	6.6	1.6	5.8
8189	25-30	9.6	8.4	82.0	LS	0.50	1.7	3.8	0.8	1.4
8190	30-35	9.6	14.4	76.0	SL	0.50	0.8	6.0	0.8	5.2
8191	35-40	11.6	15.2	73.2	SL	0.50	4.7	4.0	1.4	16.2
8192	40-45	33.6	26.8	39.6	CL	0.50	6.0	55.0	1.8	15.4
8193	45-50	41.2	32.4	26.4	C	0.50	6.0	30.0	4.8	5.4
8194	50-55	41.2	28.0	30.8	C	0.50	6.0	26.0	3.7	7.6
8195	55-60	44.4	30.0	25.6	C	0.25	6.0	31.0	4.2	5.8
Coal	60-84									
8196	84-90	30.6	30.2	39.2	CL	1.25	6.0	30.0	1.8	5.4
8197	90-95	24.4	53.2	22.4	SiL	0.25	6.0	52.0	3.4	8.9
8198	95-100	22.0	48.4	29.6	L	0.25	24.0	55.0	2.0	8.2
8199	100-105	27.2	41.6	31.2	CL	0.25	50.0	40.0	2.3	9.2
8200	105-110	22.4	53.6	34.0	L	1.85	11.5	42.5	1.4	6.7

Table 21 Chemical Analysis of Overburden Materials Associated with Coal Areas. Western Energy Coal Company, Area E-2

Hole # N47,850 E59,150

Lab No.	Depth feet	Ex. NH_4 (ppm)	Se (ppm)	Hg (ppb)	B (ppm)	Pb (ppm)	Cd (ppm)	Ni (ppm)	Mo (ppm)	CEC meq/100
8184	0-5	10.0	0.5	8.0	0.7	0.7	0.1	0.5	0.26	8.7
8185	5-10	45.0	0.5	8.0	0.8	0.8	0.1	0.5	0.21	11.5
8186	10-20	11.0	0.5	14.0	0.9	1.0	0.1	0.5	0.18	14.0
8187*										
8188	20-30	9.0	0.5	14.0	0.5	0.8	0.1	0.5	0.08	4.0
8189*										
8190	30-35	14.0	0.5	14.0	0.4	0.8	0.1	0.5	0.10	2.5
8191	35-40	14.0	0.5	8.0	0.4	0.8	0.1	0.5	0.10	4.0
8192	40-45	19.0	0.5	8.0	0.6	4.4	0.1	3.0	0.10	9.5
8193	45-50	23.0	0.5	8.0	0.8	5.6	0.1	3.2	0.08	14.0
8194	50-55	15.0	0.5	18.0	0.8	6.6	0.1	1.4	0.04	11.5
8195	55-60	18.0	0.5	24.0	0.9	8.8	0.1	1.2	0.22	12.0
Coal Seam	60-84									
8196	84-90	22.0	0.5	14.0	1.2	7.2	0.1	1.0	0.30	7.0
8197	90-95	40.0	0.5	14.0	1.0	5.4	0.1	2.4	0.62	6.0
8198	95-100	63.0	0.5	8.0	0.9	3.6	0.1	2.0	0.50	5.7
8199	100-110	41.0	0.5	8.0	1.0	2.1	0.1	1.2	0.43	7.5
8200*										

* Depths combined for chemical analysis.

Hole # N49,600 E59,100 (Tables 22, 23 & 24)

Electrical conductivity was 4.2 mmhos/cm at 0-5' and separation of top soil should be made according to horizon information. The remaining depths from this hole are low in salts and should not restrict plant growth if other results show favorable.

Sodium Adsorption Ratio is low and should not restrict plant development by through low water intake, root development or seedling establishment.

Textures are favorable for water intake and plant growth. Textures consist mainly of loamy sand, sandy loam, occassional silt loam , and sandy clay loam.

Nitrate nitrogen is considered very low except at 10-30', 40-45' and 65-70' where levels of 5.5 to 19.5 ppm of nitrate nitrogen were found. These levels are high enough to support plant growth for at least one year. They could be a potential nitrate hazard in water if not properly used by crops or placed near the surface during mining. These depths should not be placed immediately above a clay layer which may restrict water movement downward.

The Exchangeable ammonium was depleted in some depths and it may be possible that it was converted to nitrate after drilling was completed if sample was left exposed to air for a period before analysis was completed. It could be possible also that nitrates could be leached and accummulated at these depths. This is very possible especially if the terrain where the samples were taken was concave and collected run off moisture. The location of some of these nitrates however are not consistent throughout the hole which makes leaching and accummulation questionable. For example, the nitrates are high at both 40-45' and 65-70' depths and very low immediately above or below the depth. This could be due to analytical error, sampling contamination or nitrification of exchangeable ammonium during storage of samples. At any rate these soils should be used appropriately.

Zinc (DTPA chelatable) was exceptionally high at 80-82' and 120-125' with 200 and 600 ppm Zn. These depths happen to be immediately above the Rosebud and McKay coal seams and should not be placed near the surface. Other depths containing zinc near 30 ppm were 60-70' and 75-80'.

Iron was low at all depths except for 65-70' depth with 148 ppm iron. Agriculturally productive soil in Montana contains as high as 50 ppm on the surface 6 inches and sometimes higher without sacrificing plant growth. Levels of toxicity of iron are not definitely defined.

Copper and manganese are low and should not restrict plant growth.

Selenium is less than 0.5 ppm and should not restrict plant growth.

Mercury is less than 32 ppm and should not restrict plant growth.

Boron is less than 1.3 ppm and well below anticipated level of problems.

Lead levels at 50-82' exceeded 2 ppm and may offer some resistance to plant growth.

Cadmium is all less than 0.1 ppm except 120-125' with 0.2 ppm. Although this level is considered potentially hazardous, mixing this depth with the above soil should prevent any level high enough to restrict plant growth.

(Holo # 49,600 E59,100, continued)

Nickel is less than 2 ppm and should not restrict plant growth.

Molybdenum is below 1 ppm and should not restrict plant growth.

SUMMARY

1. Soluble salts were present only on the top five feet and information obtained from horizon analysis should be used to determine top soil potential.

2. Nitrate accumulation found at 10-30', 40-45', and 65-70'. Nitrate accumulation of 5.5 to 19.5 ppm were found. These levels can support plant growth for a year and if placed near rooting zone, nitrogen requirement should be adjusted.

3. Exchangeable ammonium is lower than normally found and nitrification of samples during storage is anticipated.

4. Zinc was exceptionally high at 80-82' and 120-125' with 200 and 600 ppm Zn. These levels occur immediately above the Rosebud and McKay coal seams and should not be permitted to be placed near the surface.

5. Lead levels exceeded 2 ppm at 50-82' and may offer some resistance to normal plant growth.

Table 22 Chemical Properties of Soil and Overburden Materials Associated with Coal Areas.
Western Energy Area B Hole # N49,600 E59,100

Lab No.	Depth	pH Paste	Sat'n.	Elect. Cond.	Saturation Extract			
					Cations			
					Ca	Mg	Na	SAR
	feet		%	mmhos/cm	- - - - - - meq/liter - - - - - -			
8201	0-5	8.3	33.5	4.20	1.3	2.4	0.4	0.30
8202	5-10	8.3	30.8	1.07	5.2	3.8	2.3	1.00
8203	10-15	8.2	30.1	0.80	3.0	3.1	1.4	0.77
8204	15-20	8.2	31.9	0.80	2.3	3.7	0.6	0.36
8205	20-25	8.0	28.6	0.90	5.0	2.9	0.2	0.09
8206	25-30	8.4	27.7	0.40	0.5	2.3	0.3	0.25
8207	30-35	8.6	32.3	0.23	0.1	1.6	0.5	0.43
8208	35-40	8.7	30.8	0.23	0.1	2.0	0.8	0.73
8209	40-45	8.7	28.5	0.27	0.1	1.8	0.7	0.70
8210	45-50	8.5	29.3	0.50	0.8	2.6	0.7	0.54
8211	50-55	8.2	32.0	1.10	4.1	5.5	1.0	0.21
8212	55-60	8.2	33.5	0.90	4.5	4.4	1.0	0.43
8213	60-65	8.2	30.9	0.90	2.1	4.1	1.4	0.77
8214	65-70	8.1	33.6	0.93	2.3	3.9	1.7	0.94
8215	70-75	8.2	25.2	1.00	2.1	3.6	2.5	1.49
8216	75-80	7.8	27.4	1.90	10.1	9.1	3.7	1.19
8217	80-82	7.9	26.6	1.60	7.1	7.6	3.4	1.26
8218	105-110	7.9	25.0	1.80	7.8	6.6	6.6	2.46
8219	110-115	8.3	27.4	1.30	3.1	2.8	6.3	2.33
8220	115-120	8.1	28.7	1.10	4.3	3.5	6.7	3.55
8221	120-125	8.2	23.7	1.20	2.8	2.9	4.8	2.82

Coal 82-105'

Table 23 Results of Mechanical Analysis (Hydrometer Method) with Nitrates and Micro Nutrients (Zinc, Iron, Copper, and Manganese) for Overburden Samples. Western Energy Coal Company. Area E-2.

Hole # N49,600 E59,100

Lab No.	Depth feet	% Clay	% Silt	% Sand	Texture	NO_3	Zn	Fe	Cu	Mn
8201	0-5	7.6	12.8	79.6	LS	0.25		3.2	1.6	2.0
8202	5-10	11.6	10.8	77.6	SL	0.25	1.7	3.9	1.1	1.8
8203	10-15	5.4	8.8	85.8	LS	5.50	0.01	3.2	0.9	1.8
8204	15-20	5.8	15.8	78.4	LS	7.50	1.2	2.6	0.9	2.0
8205	20-25	10.6	10.4	79.0	SL	19.50	6.0	3.0	1.0	3.2
8206	25-30	16.4	15.0	68.6	SL	5.00	4.1	2.0	1.5	1.8
8207	30-35	6.8	8.2	85.0	LS	0.25	2.0	2.8	0.6	1.2
8208	35-40	11.6	6.2	82.2	SL	0.25	13.0	3.9	0.8	2.4
8209	40-45	7.6	8.8	83.6	LS	11.00	6.8	4.0	1.2	2.0
8210	45-50	11.0	10.8	78.2	SL	0.25	5.0	2.2	1.1	2.8
8211	50-55	10.6	14.4	75.0	SL	0.25	3.2	15.8	2.9	6.2
8212	55-60	16.0	12.8	71.2	SL	0.25	3.3	29.2	3.4	9.5
8213	60-65	12.6	18.8	68.6	SL	0.25	33.8	26.8	3.6	9.2
8214	65-70	16.6	10.8	72.6	SL	19.50	28.6	148.0	4.5	11.1
8215	70-75	14.8	57.2	28.0	SiL	0.25	3.8	5.2	3.6	6.7
8216	75-80	27.2	52.8	20.0	CL	0.25	29.2	19.9	4.6	7.4
8217	80-82	25.6	23.2	51.2	SCL	0.25	200.0	2.6	4.8	11.1
Coal	82-105									
8218	105-110	23.2	13.6	63.2	SCL	0.25	2.1	16.6	2.0	6.4
8219	110-115	11.6	19.8	68.6	SL	0.25	13.0	26.8	6.0	6.7
8220	115-120	12.6	22.2	65.2	SL	0.25	4.4	38.0	2.8	5.2
8221	120-125	11.2	21.8	67.0	SL	0.25	600.0	30.0	1.6	11.1

Table 24 Chemical Analysis of Overburden Materials Associated with Coal Areas. Western Energy Coal Company, Area E-2

Hole # N49,600 E59,100

Lab No.	Depth feet	Ex.NH (ppm)	Se (ppm)	Hg (ppb)	B (ppm)	Pb (ppm)	Cd (ppm)	Ni (ppm)	Mo (ppm)	CEC meq/100gr
8201	0-5	6.0	0.5	18.0	0.2	0.7	0.1	0.5	0.04	10.3
8202	5-10	7.0	0.5	18.0	0.3	0.6	0.1	0.5	0.03	5.5
8203	10-20	8.0	0.5	32.0	0.2	0.6	0.1	0.5	0.07	4.8
8204*										
8205	20-30	10.0	0.5	18.0	0.3	0.6	0.1	0.5	0.06	6.3
8206*										
8207	30-40	11.0	0.5	14.0	0.3	0.5	0.1	0.5	0.04	5.0
8208*										
8209	40-45	6.0	0.5	18.0	0.2	0.7	0.1	0.5	0.03	4.0
8210	45-50	7.0	0.5	14.0	0.3	0.9	0.1	0.5	0.03	3.5
8211	50-60	23.0	0.5	8.0	0.3	2.0	0.1	1.4	0.06	5.0
8212*										
8213	60-65	33.0	0.5	6.0	0.3	3.2	0.1	1.6	0.09	5.0
8214	65-70	28.0	0.5	14.0	0.3	3.2	0.1	1.8	0.11	4.7
8215	70-75	21.0	0.5	14.0	0.4	1.9	0.1	1.2	0.11	3.0
8216	75-82	24.0	0.5	20.0	0.6	3.0	0.1	2.0	0.02	5.0
8217*										3.5
Coal Seam	82-105									
8218	105-110	18.0	0.5	6.0	1.1	1.5	0.1	0.8	0.02	3.5
8219	110-120	18.0	0.5	14.0	0.9	1.3	0.1	0.8	0.05	2.5
8220*										
8221	120-125	23.0	0.5	6.0	1.3	0.3	0.2	0.6	0.04	3.5

* Depths combined for chemical analysis

Hole # N51,300 E60,200 (Tables 25, 26, & 27)

Soluble salts are very low and anticipate all crops and grasses to perform well.

Sodium Adsorption Ratio are also very low and expect very little crusting from dispersion of soils.

Textures are considered favorable for all except at 165-169' where heavy clay texture was present. It occurs below the second coal seam and should not be permitted for use near the surface.

Nitrate nitrogen is considered very low on all depths and should not be potentially hazardous for underground water or surface run off into streams.

Exchangeable ammonium is present on all depths and nitrogen application or requirement for grass extablishment should be adjusted.

Selenium, mercury, boron, cadmium, molybdenum are all below expected level to restrict plant growth and should not present any problem.

Lead exceeded 5 ppm at 70-75', but if it is mixed with soil above and below this depth, it should not restrict plant growth.

EDPA chelatable Nickel exceeded 100 ppm at 10-30' and 65-132'. The only oth depth that exceeded 5 ppm was at 111-115' immediately above the first coal seam. These depths should not be permitted to be used near the surface. Values above 1.0 ppm should be used with caution until better understanding of the relative values are obtained.

SUMMARY

1. Soil contains very low soluble salts which should not restrict plant growth.

2. Exchangeable ammonium is present and can be potentially hazardous to underground water or stream run off oa nitrate if not properly placed and used by plants.

3. Clay texture at 164-169' should not be permitted to be placed near the surface. This layer was found immediately below the second coal seam.

4. Lead exceeded 5 ppm ab 70-75' but if it is mixed with soil above and below this layer, it should dilute the concentration and not restrict plant growth.

5. Nickel exceeded 5 ppm at 111-115' , above the first coal seam. This layer should not be permitted for use near the surface.

Table 3: Chemical Properties of Soil and Overburden Materials Associated with Coal Areas.
Western Energy Area B Hole # N51,500 E60,200

Lab No.	Depth	pH Paste	Sat'n.	Elect. Cond.	Saturation Extract Cations Ca	Mg	Na	SAR
	feet		%	mmhos.cm	- - - - - meq/liter	- - - - -		
8222	0-5	8.3	30.0	0.32	1.6	0.9	0.7	0.63
8223	5-10	8.4	24.0	0.50	1.5	2.7	1.7	1.13
8224	10-15	8.4	31.8	0.20	1.0	2.4	1.4	1.07
8225	15-20	8.6	33.5	0.30	0.1	1.4	1.1	1.22
8226	20-25	8.6	27.4	0.20	0.6	0.7	0.9	1.14
8227	25-30	8.7	32.1	0.75	0.1	0.9	0.8	1.12
8228	30-35	8.6	39.9	1.50	0.1	1.4	0.8	1.00
8229	35-40	8.7	30.2	1.75	0.1	1.1	0.7	0.86
8230	40-45	8.2	32.0	1.00	1.6	2.6	0.8	0.53
8231	45-50	8.4	33.9	0.20	1.9	2.8	0.8	0.53
8232	50-55	8.5	28.5	0.50	0.6	1.2	0.7	0.72
8233	55-60	8.5	21.1	0.40	0.5	0.9	0.6	0.71
8234	60-65	8.5	32.1	0.30	1.0	1.6	0.6	0.44
8235	65-70	8.3	32.0	1.40	3.1	3.0	0.8	0.46
8236	70-75	8.4	30.3	1.00	2.1	2.4	1.2	0.78
8237	75-80	8.3	27.0	1.00	3.0	3.1	1.4	0.77
8238	80-85	8.2	28.7	1.50	6.0	5.5	1.6	0.57
Coal	85-111							
8239	111-115	7.5	34.7	1.90	11.1	8.1	1.7	0.55
8240	115-120	8.0	31.4	1.20	3.1	8.6	1.5	0.62
8241	120-125	7.8	32.2	1.40	5.4	4.8	1.9	0.83
8242	125-130	8.0	35.3	1.40	5.0	5.3	2.0	0.87
8243	130-132	8.2	30.6	1.20	3.9	3.5	2.4	1.26
8244	164-169	7.4	50.8	2.20	9.1	8.3	4.4	1.48
8245	169-174	7.5	29.4	3.75	28.8	18.3	6.3	1.29

26

Table 26 Results of Mechanical Analysis (Hydrometer Method) with Nitrates and Micro Nutrients (Zinc, Iron, Copper, and Manganese) for Overburden Samples. Western Energy Coal Company. Area E-2

Hole # N51,300 E60,200

Lab No.	Depth	% Clay	% Silt	% Sand	Texture	NO_3	Zn	Fe	Cu	Mn
8222	0-5	11.6	10.6	77.8	SL	0.25	10.5	4.9	0.6	2.4
8223	5-10	23.2	21.6	55.2	SCL	0.25	132.5	66.0	1.8	24.0
8224	10-15	31.2	28.8	40.0	CL	0.25	3.4	30.0	1.0	7.4
8225	15-20	5.6	17.2	77.2	LS	0.25	0.7	13.3	2.4	4.2
8226	20-25	11.2	11.0	77.8	SL	0.25	3.5	12.8	1.0	3.4
8227	25-30	7.8	6.6	85.6	LS	0.25	0.9	10.0	0.8	2.8
8228	30-35	9.2	8.0	82.5	LS	0.25	1.0	11.5	0.9	3.2
8229	35-40	6.6	8.0	85.4	LS	0.25	0.4	13.5	0.6	3.4
8230	40-45	32.0	43.6	24.4	CL	0.25	20.0	112.0	3.2	16.5
8231	45-50	32.0	38.8	29.9	CL	0.25	5.2	115.0	2.5	10.2
8232	50-55	10.0	8.8	81.2	LS	0.25	0.2	24.0	0.4	5.4
8233	55-60	4.2	15.0	80.8	LS	0.25	1.2	19.2	0.8	4.8
8234	60-65	6.0	11.4	82.6	LS	0.25	1.1	12.8	0.6	3.6
8235	65-70	6.8	10.6	82.6	LS	0.25	2.2	38.0	0.8	3.2
8236	70-75	9.2	13.0	77.2	SL	0.25	5.3	40.0	0.6	2.8
8237	75-80	8.0	14.0	74.0	LS	0.25	11.5	38.0	1.1	3.4
8238	80-85	12.0	15.2	72.8	SL	0.25	28.0	32.0	2.6	3.2
Coal	85-111									
8239	111-115	20.2	41.6	38.2	L	0.25	11.5	60.0	2.2	10.0
8240	115-120	16.4	45.8	37.8	L	0.25	2.1	55.0	4.0	9.5
8241	120-125	13.2	50.8	36.0	SiL	0.25	92.5	90.0	3.8	13.1
8242	125-130	22.8	42.8	34.4	L	0.25	1.9	78.0	4.0	11.1
8243	130-132	15.2	17.6	67.2	SL	0.25	1.1	55.0	4.8	8.2
Coal	132-164									
8244	164-169	47.6	28.6	23.6	C	0.25	11.2	55.0	3.8	7.4
8245	169-174	31.0	20.6	48.4	SCL	0.25	1.2	40.0	4.0	8.0

Table 27 Chemical Analysis of Overburden Materials Associated with Coal Areas. Western Energy Coal Company, Area E-

Hole #N51,300 E60,200

Lab No.	Depth feet	Ex.NH4 (ppm)	Se (ppm)	Hg (ppb)	B (ppm)	Pb (ppm)	Cd (ppm)	Ni (ppm)	Mo (ppm)	CEC meq/100gr
8222	0-5	49.0	0.5	14.0	0.5	0.6	0.1	0.5	0.08	5.0
8223	5-10	24.0	0.5	14.0	0.8	0.6	0.1	0.5	0.06	6.0
8224	10-15	22.0	0.5	28.0	0.7	0.7	0.1	1.6	0.11	6.5
8225	15-20	10.0	0.5	58.0	0.8	0.6	0.1	1.8	0.11	4.5
8226	20-25	10.0	0.5	162.0	0.7	0.6	0.1	1.4	0.11	4.3
8227	25-30	10.0	0.5	86.0	0.4	0.6	0.1	2.0	0.14	3.7
8228	30-40	14.0	0.5	64.0	0.5	0.6	0.1	0.8	0.40	4.0
8229*										
8230	40-50	34.0	0.5	20.0	0.5	2.4	0.1	0.8	0.19	10.5
8231*				20.0						
8232	50-60	12.0	0.5	20.0	0.4	0.7	0.1	0.6	0.06	3.3
8233*										
8234	60-65	17.0	0.5	14.0	0.4	0.7	0.1	0.5	0.07	2.5
8235	65-70	14.0	0.5	14.0	0.4	1.0	0.1	1.8	0.04	1.6
8236	70-75	16.0	0.5	20.0	0.4	9.0	0.1	1.6	0.04	2.0
8237	75-85	18.0	0.5	20.0	0.3	1.2	0.1	1.2	0.03	1.8
8238*										
Coal Seam	85-111									
8239	111-115	31.0	0.5	6.0	2.0	4.4	0.1	7.0	0.04	5.8
8240	115-120	44.0	0.5	6.0	0.6	3.2	0.1	1.8	0.05	3.5
8241	120-125	44.0	0.5	6.0	1.2	2.0	0.1	1.4	0.11	4.5
8242	125-130	40.0	0.5	6.0	0.8	3.0	0.1	1.4	0.15	4.2
8243	130-132	43.0	0.5	14.0	0.7	2.0	0.1	1.6	0.15	3.2

* Depths combined for chemical analysis

APPENDIX (1)

1. pH is a measure of hydrogen ion activity. Productive soils have a pH in the range 6.0 to 8.0. For Great Plains soils, pH less than 6 is uncommon while values higher than 8.2 may indicate a problem, e.g. undesirable soluble carbonate content, low solubility of calcium salts, nutritional imbalance, etc. Determinations were made on water-saturated materials.
2. $CaCO_3$ (equivalent) evaluates alkaline earth carbonate concentration expressed as $CaCO_3$. Included are calcite, dolomite, and possible magnesite. Alkaline earth carbonates are important as a potential source of calcium and magnesium for replacement of adsorbed sodium (exchangeable sodium) on the cation exchange complex of clay minerals.
3. Particle size analysis diagnoses the textural properties, i.e. sandy loam, clay loam, clay, etc. When clay content (particles < 0.002mm) is greater than 40%, the material is classed as clay and generally has associated agronomic problems of poor tilth and restricted infiltration.
4. Saturation or the amount of water required to saturate the material, expressed as percentage by weight, is influenced by particle size (texture), organic matter content, chemical, and mineralogical composition. Extremely high values may indicate high clay content of montmorillonitic mineralogy, with high quantities of exchangeable sodium.
5. Electrical conductivity (EC) is directly related to the concentration of electrolytes in solution. The EC, expressed as millimhos per cm as 25c, of saturation extracts is used for appraising the effect of salinity on plant growth. EC less than 2 has negligible effect, 2 to

4 is considered slightly saline, 4 to 8 is moderate, 8 to 16 is severe because only tolerant plants will grow satisfactorily, and values over 16 indicate very severe salinity.

Electrical conductivity of the soil solution or extract is a function of the salt content of the soil and related to plant growth potential of each soil. The conductivity of these extracts are grouped for crops that are restricted to under 4 mmhos/cm or those that can exceed 8 mmhos/cm. Soil containing greater than 4 mmhos/cm is considered "moderately saline" and will decrease plant growth and production. It is believed that salts generally affect plant growth either by (1) decreasing the availability of water to plants by increasing solute suction and causing the plant to require more energy to absorb and translocate water; (2) salts act within the plant by lowering the free energy of internal water and preventing physiological processes that require water; and (3) some ions are directly toxic to plants.

6. Cationic concentration (Na, Ca, Mg) of water extracts at saturation gives information on the composition of soluble salts and of exchangeable or adsorbed cations in the material.

7. Sodium Adsorption Ratio (SAR) is an empirical relationship to express the relative activity of sodium ions in exchange reactions with soil when the soil is at equilibrium with its solution. The SAR is calculated by the formula:

$$SAR = Na/\sqrt{(Ca+Mg)/2}$$

Ionic concentrations are expressed in milliequivalents per liter (meq/l) of solution. Because SAR is usually highly correlated with exchangeable sodium percentage, values greater than about 10-12 indicate potential problems in structural stability and permeability. Soils that have excessive concentrations of sodium are called "alkali". When sodium becomes the dominant cation in the soil solution or the exchange complexxes of soil, it will exceed 15% of the exchangeable cation. The relative proportion of sodium increases as the calcium and magnesium activity decreases by precipitation when soil solution becomes more concentrated. As the calcium and magnesium activity decrease, the sodium cation will become more dominant (greater than 50%) and replace calcium and magnesium cation on the exchange complex by "mass action". Therefore SAR is a measurement of this ratio and is used to locate and predict those problems that can be injurious for plant development. Soils having SAR greater than 10 are expected to have some problems and reclamation by correcting drainage and addition of gypsum or other amendments will be required. High sodium values will disperse the fine particles and cause crusting of soils and other poor physical properties associated with it.

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(1) Lignite Mine Spoils in the Northern Great Plains- Characteristics and Potential for Reclamation by F.M. Sandoval, J.J.Bond, J.F.Power & W.O. Willis, Northern Great Plains Research Center; Agricultural Research Service, USDA, Mandan, N. Dakota.

OVERBURDEN ANALYSES AND DISCUSSION
OF DRILL HOLE NOS. N43E69 and N51E61
MINE AREA

from

WESTERN ENERGY COMPANY'S
1973
MONTANA STRIP MINING PERMIT APPLICATION

OVERBURDEN AND INTERBURDEN ANALYSIS AS RELATED TO REVEGETATION

Justification:

Undesirable soil characteristics such as high sodium (SAR), high salt, high percentage of clay, structures that cause very little water intake, and low fertility may inhibit reclamation. This soil analysis and the plant growth study were conducted to evaluate the potential reclamation problems that may occur from overburden and interburden materials.

Methods and Materials:

Two sets of samples were collected for each mining area by the Western Energy Company. Samples were taken at 12" increments until the coal was contacted. The samples were composited by depth according to the layers and related to the log that was provided by the Western Energy Company. Not more than 10 feet intervals were composited when the layer was almost the same throughout the interval. Occasionally, when the soil was sandy, samples from more than 10 feet were compiled. One set of samples, Area Pit #6 A10, was taken at 10 foot increments. Analysis and report were made accordingly.

Sample Preparation:

Samples were air dried and divided into two by taking alternate 6 inches of soil from each 12" tube. One half was kept in the plastic tube for future use and the other half was prepared for the complete soil analysis.

When necessary, samples were crushed to 1" by a jaw crusher, mixed and then divided into the following portions:

1. 500 grams for weathering and screen analysis wherever desired.
2. 500 grams screened (<9 mesh) for mechanical analysis.
3. Screen <12 mesh and divide into two - one half for greenhouse study and the other half for laboratory analysis.
4. Samples for laboratory analysis were screened to 20 mesh size. Samples designated for greenhouse could also be used for the weathering tests wherever desired.

5. 100 grams were sent to the U. S. Testing Lab for trace elements analysis.

6. For mechanical analysis, samples were screened to size 9 mesh.

Chemical Analysis

1. pH and conductivity - soil to solution of ratio 1:2.

2. Sodium Adsorption Ratio - (qualified by sodium content).

3. Sodium Exchange Potential - (calculate if necessary - CEC also). This has the same interpretation value as SAR.

4. Macro Analysis - organic matter, nitrate, phosphorous, potassium, calcium, magnesium, sodium, sulfur.

5. Micro Analysis - copper, iron, manganese, zinc, aluminum, barium, cadmium, lead, mercury, silicon, strontium, titanium, selenium, fluoride, molybdenum, arsenic, boron.

6. Soluble Salts.

7. CEC.

8. Mechanical Analysis.

9. Water Holding Capacity, at 0.33 bar and 15 bar suction (method developed by Gordon Decker "Automatic Retrieval and Analysis of Soil Characterization Data" PhD Thesis Montana State University, Bozeman, Montana, December 1972).

10. Plant Growth Tests.

a) 500 grams of air dry soil (or less if 500 grams of soil were not available).

b) Add 50 ppm P as concentrated super phosphate.

c) Add 50 ppm N as NH_4NO_3 on weekly basis.

d) Seeded to Winoda winter wheat 6 seeds/pot.

e) Water with distilled water to 0.33 bar or field capacity and weight maintained on daily basis.

f) Harvest - Report dry weight, tillers, and stand.

RESULTS AND DISCUSSION AREA A1:

Hole #N52E50 Lab No. 1595-1604 - A1-1

Hole #N51E53 Lab No. 1630-1637 - A1-2

RESULTS AND DISCUSSION AREA E

Hole #N43-E69 Lab No. 1605-1614

Hole #N51-E61 Lab No. 1638-1651

Western Energy Company Test Hole Data: Drill Hole No. N43 E69

Prospect: Area E

Date: 9-12-73

Depth, feet	Formation Record	Sample Depth, ft.	Montana Testing Lab No.
0-69			
0-46	Light brown, fine grained sandstone	0-10	1605
		10-20	1606
		20-30	1607
		30-43	1608
		43-46	1609
46-69	Gray sandstone & shale	46-56	1610
		56-60	1611
		60-65	1612
		65-68	1613
		68-69	1614

Western Energy Company Test Hole Data: Drill Hole No. N51 #61

Prospect: Area E

Date: 9-13-73

Depth, feet	Formation Record	Sample Depth, ft.	Montana Testing Lab No.
0-36	Light brown fine grained	0-10	1638
		11-20	1639
		21-30	1640
		31-36	1641
36-38	Gray shale & sandstone	37-38	1642
38-47	Light brown fine grained	38-47	1643
47-53	Gray shale & sandstone	47-53	1644
53-56	Light brown fine grained sandstone	53-56	1645
		56-70	1656
56-91	Gray sandstone & shale	71-80	1647
		81-85	1648
		85-87	1649
		88-89	1650
		90-91	1650

Chemical and Physical Analyses

1. pH values in both holes are high and suggest the presence of sodium and/or toxic trace elements such as aluminum. (pH is used to predict excess iron or aluminum that may interfere with the availability of phosphorous and high sodium concentrations that may affect the water intake of the soil).

2. Sodium Adsorption Ratio (SAR) - Because pH values were high, SAR values were suspected to be high as well. However, ammonium acetate sodium concentrations were less than 0.3 me/100 gm of soil and SAR values were less than 2.0. No problem associated with sodium dispersion of soil particles causing low hydraulic conductivity and low water intake are anticipated.

3. Sodium Exchange Potential - Not applicable to these soils because the SAR values were very low.

4. Macro Analysis - Organic Matter was very low on all samples. Organic matter increases as it approaches the coal seam due to reasons given previously.

Nitrate-Nitrogen is very low at all depths.

Supplemental Nitrogen will be required.

Phosphorous, Potassium, Calcium, Magnessium, and Sulfur - Sodium bicarbonate extractable phosphorous is less than 1.0 ppm on all depths. This soil is very deficient in phosphorous and may require one or two annual applications for two years.

The available potassium is considered low in both holes in Area E. After mixing, it is very important that potassium become part of the fertilizer requirement in establishment of permanent cover.

Calcium and magnesium levels are well within the range found in Montana soils. No layer or depth indicate unusual concentration and should not present any growth establishment problem.

Sulfur is very high throughout the lower depth. If the lower depth (10') is to be mixed with the surface soil, additional sulfur may not be required. In this area it is suggested that only the upper 5 feet of top soil be stockpiled.

5. Micro Analysis - EDTA extractable - The micro nutrient extractable DTPA do not show deficiencies in any depth in both holes of Area E. The iron concentration increases in the layer where clay content is higher. The levels found in this layer will not cause any toxicity to plant growth but this layer should be separated from others as carefully as possible. The layer above this dense clay layer should be separated with caution.

No unusual amounts of other trace elements were found in these soils that would cause deficiency or toxicity to plant growth.

6. Soluble Salts - Soluble salts were low (less than 2 mmhos/cm) at all depths from the two holes taken in Area E. Very little salt problems are anticipated but if soil appears white, it is probably related to high sulfur sulfate in the profile.

7. CEC - Cation Exchange Capacity is not applicable to these soils.

8. Mechanical Analysis - Holes #N43E69 and #N51E61 contain a layer high in clay. It contains a clay loam layer at a depth of 43 to 46 feet. It is not a very dense clay layer but may restrict water intake. Hole #N51E61 contains a high percent clay layer that should not be permitted to be within the top 8' of soil. This layer is located at a depth of 48-53 feet. It is desirable that this clay layer be mixed with some coarse textured soil and be placed below 8 feet from the surface. Percent of clay could be reduced by intermixing layers that will cause changes in texture and composition.

The layer above the coal seam did not exhibit a high percent of clay (26.8%) and sodium and salt concentrations were very low.

9. Water Holding Capacity - The suction between 0.33 and 15 bars represents the amount of water held by the soil and available to the plant. The loamy sands and sandy loams will have low holding capacities while the clay loams and clays will exhibit very high water holding capacities.

10. Plant Growth Test - In progress. No plant growth problems associated with salt, sodium, or low hydraulic conductivity are anticipated from the layer that contains high clay content.

Report will be submitted separately when completed.

RECOMMENDATION:

1. The clay layer found in Hole #N51E61 should not be permitted to be placed near the surface. It is desirable to mix it with sandy soil and place it at lower depths.

2. Trace elements seem to increase as clay content increases. Careful sampling of all dense layers above it is recommended. It should be emphasized that two samples tested, Lab No. 1644 and 1651, Table 2, showed high levels of boron (6.3 ppm and 23.0 ppm, respectively). This should be checked for, and if levels >4.0 ppm are found in other locations during reclamation, those portions should not be replaced near the bed of the restored Rosebud aquifer (to prevent the chance of future leaching out) nor closer than 8 feet of the surface.

3. The parting layer did not have high levels of SAR or salt. Percent clay seems to be higher but will not lower hydraulic conductivity and water intake from the level found.

4. See stockpiling recommendations that accompany the soil descriptions.

Date Rec'd. [illegible]-75
Date Sent

RESULTS
DEEP SOIL SAMPLE ANALYSIS

FROM:
Montana Testing [illegible]
P. O. Box [illegible]
Great Falls, Montana [illegible]

FROM: (Grower) [illegible] Energy Co.

Area E Overburden N 43 E 69

CLIENT: (Dealer)

Lab No.	[illegible] No.	Depth (inches)	pH	Organic Matter %	Nitrate Nitrogen ppm	Lbs./Ac. N	Phosphorus P ppm	Potassium K ppm	Calcium Ca meq/100g	Magnesium Mg meq/100g	Sodium Na meq/100g	Salt Hazard mmhos	Soil Texture	L
1605		0-10	8.6	0.1	0.5		0.03	83	28.9	3.8	0.1	0.4	LFS	[illegible]
1606		10-20	9.0	0.1	0.5		0.03	113	30.7	4.6	0.1	0.4	FSL	V.
1607		20-30	8.9	0.1	0.25		0.03	113	21.1	3.0	0.1	0.3	LFS	H
1608		30-43	8.9	0.1	0.5		0.03	113	21.5	3.0	0.1	0.3	SL-	M+
1609		43-46	8.7	0.1	0.25		0.03	88	+35	4.6	0.1	0.5	L	M+
1610		[illegible]	[illegible]	[illegible]	0.25		0.08	113	28.9	3.4	0.1	0.4	L+	V
1611		50-60	8.7	1.3	0.25		0.03	88	24.5	3.4	0.1	0.6	L+	M+
1612		60-65	9.0	0.1	0.25		0.03	113	13.0	2.5	0.1	0.5	VFSL	M-
1613		65-[illegible]	8.8	0.1	0.25		0.08	113	3.3	2.7	0.3	0.6	FSL	O
1614		[illegible]-69	8.7	0.8	0.25		0.03	88	1.6	3.2	0.1	0.6	SL	O

OTHER TESTS REQUIRED

Sulfur ppm	Zinc ppm	Iron ppm	Copper ppm	Manganese ppm	Boron ppm	0.3 ATM	15 ATM	[illegible] SAR	Cation Exchange Capacity (CEC)	Mechanical Analysis % Clay	% Silt	% Sand	Others
18.2	6.0	4.9	1.8	2.8		7.8	3.9	1.28		12.8	2.4	84.8	LS
7.4	20.6	21.2	1.8	8.6		9.0	4.5	0.92		14.8	8.4	76.8	SL
4.1	5.2	5.8	1.2	2.8		7.8	3.9	0.72		12.8	2.4	84.8	LS
7.0	0.8	10.2	1.4	8.0		6.8	3.4	0.85		10.8	0.4	88.8	LS
10.2	27.5	61.3	2.2	11.7		18.4	9.2	0.84		30.8	30.4	38.8	CL
11.3	[illegible]	47.5	2.3	5.8		14.84	7.42	0.85		24.8	16.4	58.8	SCL
[illegible]	2.6	21.5	2.3	4.4		16.2	8.1	0.59		26.8	24.4	48.8	L
[illegible]	9.4	12.0	1.0	1.8		7.8	3.9	0.80		12.8	14.4	72.8	SL
63.3	6.0	14.0	1.4	2.0		7.0	3.9	0.50		12.8	10.4	76.8	SL
55.0	3.7	23.0	3.2	2.4		9.1	4.55	0.53		14.8	0.4	84.8	LS

WESTERN ENERGY AREA E OVERBURDEN, MICRONUTRIENTS

5e

N43 E69

Lab No.	Depth	Ba	As	B	Ti	Mo	Sr	SiO4	F	Water soluble F	Hg	Pb	Cd	Al
605	0-10	7.5	2.0	0.5	< 1	0.11	7.0	68.51	432	0.68	8.0	0.4	< .5	< 1
1606	10-20	20.0	1.0	0.5	< 1	0.14	8.5	56.64	432	0.44	13.0	0.4	0.5	< 1
1607	20-30	21.0	1.0	0.3	< 1	0.09	9.0	72.58	428	0.12	10.8	0.4	0.5	< 1
1608	30-43	7.5	2.0	0.3	< 1	0.12	9.0	57.71	408	0.24	19.0	0.3	0.5	< 1
1609	43-46	12.5	4.0	0.4	< 1	0.2	10.5	56.67	544	0.02	28.0	1.6	0.5	< 1
1610	46-56	7.0	1.0	0.6	< 1	0.22	8.5	53.88	496	0.44	23.0	1.4	0.5	< 1
1611	56-60	7.0	2.0	0.6	< 1	0.25	8.5	60.95	424	0.72	33.0	1.8	0.5	< 1
1612	60-65	7.0	1.0	0.6	< 1	0.14	5.5	72.2	424	0.5	25.0	0.11	0.5	< 1
613	65-68	20.0	1.0	0.6	< 1	0.16	3.5	32.93	452	0.78	13.0	0.7	0.5	< 1
614	68-69	< 2	1.0	1.0	< 1	1.17	3.5	61.47	332	0.86	10.0	0.6	0.5	< 1

Date Rec'd 9- 12

Date Sent

RESULTS OF
DEEP SOIL SAMPLE ANALYSIS

FROM:
Montana Testing Laboratories, I
P. O. Box [illegible]
Great Falls, Montana [illegible]

To: (Owner) Western Energy Co.

Area B Overburden 551 561

CLIENT: (Dealer)

Lab No.	Your Field No.	Depth	pH	Organic Matter %	Nitrate Nitrogen ppm	Lbs./Ac. N	Phosphorus P ppm	Potassium K ppm	Calcium Ca meq/100g	Magnesium Mg meq/100g	Sodium Na meq/100g	Salt Hazards mmhos	Soil Texture	[illegible]
														LIME
[illegible]		0-10	8.7	0.1	0.25		0.08	113	34.1	8.0	0.1	0.4	FSL+	M+
[illegible]		11-20	8.6	0.1	0.25		0.80	213	25.5	4.1	0.1	0.3	LFS	M-
[illegible]		21-30	8.7	0.1	0.25		0.08	2.5	19.4	3.4	0.1	0.3	LFS	M-
[illegible]		[illegible]	8.6	0.1	0.25		0.08	63	25.9	3.2	0.1	0.4	LFS	M
[illegible]		[illegible]	8.8	0.1	0.25		0.50	63	30.2	5.0	0.1	0.5	CL-	M+
[illegible]		[illegible]	8.6	0.1	0.25		0.08	88	34.1	4.1	0.1	0.6	FSL+	M+
[illegible]		[illegible]	8.7	0.1	0.25		0.08	113	28.9	3.4	0.1	0.8	CL+	V
[illegible]		[illegible]	8.8	0.1	0.25		0.08	113	26.3	3.4	0.1	0.5	LFS	M
[illegible]		[illegible]	8.5	0.1	0.25		0.08	113	23.6	2.2	0.1	0.8	LFS	M
[illegible]		[illegible]	8.7	0.1	0.25		0.08	88	27.1	2.5	0.1	0.7	FSL	M+
[illegible]		[illegible]	8.8	0.1	0.25		0.08	188	29.4	2.7	0.1	0.8	FSL+	M+
[illegible]		[illegible]	8.8	0.1	1.25		0.08	113	28.9	2.5	0.1	0.7	L	M+
[illegible]		[illegible]	8.7	0.8	0.25		0.08	63	32.0	6.2	0.1	0.9	L	M+
[illegible]		[illegible]	8.2	5.7	0.5		0.08	113	32.4	[illegible]	0.1	0.9	L	M

OTHER TESTS REQUIRED

[illegible]	Zinc ppm	Iron ppm	Copper ppm	Manganese ppm	Boron ppm	0.3 ATM	15 ATM	Lime or Gypsum	Cation Exchange Capacity (CEC)	Mechanical Analysis % Clay	% Silt	% Sand	Others
0.6	1.3	4.0	1.8	3.6		15.5	7.75	0.49		25.8	6.4	68.8	SCL
0.6	0.6	4.9	1.2	5.2		7.96	3.98			12.8	4.4	82.8	LS
0.6	1.8	5.8	1.2	5.4		6.8	3.4			10.8	2.4	86.8	LS
[illegible]	2.6	6.0	1.6	6.1		6.8	3.4	0.39		10.8	2.4	86.8	LS
[illegible]	[illegible]	[illegible]	2.0	10.0		17.24	8.62	0.89		28.8	38.4	32.8	CL-
[illegible]	20.8	[illegible]	1.4	13.1		12.6	6.3	0.50		20.8	4.4	74.8	SCL-
[illegible]	6.0	57.5	2.5	12.4		26.2	13.2	0.61		44.8	16.4	38.8	C-
[illegible]	6.0	15.2	1.4	8.6		11.44	5.72	0.47		18.8	2.4	78.8	SL
[illegible]	[illegible]	[illegible]	1.4	4.2		9.0	4.5	0.38		14.8	0.4	84.8	LS+
[illegible]	[illegible]	27.8	4.8	3.2		9.0	4.5	0.39		14.8	0.4	84.8	LS+
[illegible]	[illegible]	20.8	2.6	3.4		10.28	5.14	2.6		[illegible]	2.4	[illegible]	SL
[illegible]	[illegible]	29.2	1.4	3.4		7.96	3.93	0.91		12.8	2.4	[illegible]	LS
[illegible]	[illegible]	30.0	2.0	2.8		17.2	8.6	1.7		28.8	2.4	[illegible]	SCL
[illegible]	[illegible]	[illegible]	5.3	6.2		16.02	8.01	1.03		24.8	2.4	[illegible]	SCL

WESTERN ENERGY AREA E OVERBURDEN, MICRONUTRIENTS (continued)

Lab No.	Depth	Ba	As	B	Ti	Mn	Sr	SiO_2	F	water sol. F	Hg	Pb	Cd	Al
1638	0-10	17.5	5.0	1.4	< 1	0.07	7.0	58.36	416	0.72	12.0	0.3	< .5	< 1
1639	11-20	11.0	2.0	0.5	< 1	0.12	5.0	64.13	0	0.44	8.0	0.3	< .5	< 1
1640	21-30	7.6	2.4	0.3	< 1	0.06	5.0	5053	0	0.20	8.0	0.4	< .5	< 1
1641	31-36	5.0	3.5	0.3	< 1	0.07	5.0	60.46	0	0.36	11.0	0.4	< .5	< 1
1642	37-38	5.0	1.0	0.4	< 1	0.22	8.5	44.49	0	0.84	20.0	0.8	< .5	< 1
1643	39-47	2.0	2.2	0.3	< 1	0.1	7.0	67.05	0	0.52	10.0	0.5	< .5	< 1
1644	48-53	5.0	1.5	6.3	< 1	0.19	10.0	33.13	0	0.52	20.0	1.6	< .5	< 1
1645	54-56	5.0	3.0	0.3	< 1	0.16	8.5	42.81	0	0.6	11.0	0.5	< .5	< 1
1646	57-70	2.0	2.0	0.4	< 1	0.22	6.0	57.65	464	0.3	16.0	0.5	< .5	< 1
1647	71-80	5.0	< 1	0.4	< 1	0.32	6.0	65.63	408	0.24	13.0	0.4	< .5	< 1
1648	81-84	3.5	1.1	0.2	< 1	0.22	6.0	49.3	0	0.4	8.0	0.8	< .5	< 1
1649	85-87	2.0	1.6	0.2	1.5	0.22	7.0	44.27	0	0.24	7.0	0.9	< .5	< 1
1650	88-89	6.0	1.0	0.5	< 1	0.25	25.0	54.69	0	0.64	50.0	1.1	< .5	< 1
1651	90-91	5.0	2.0	23.0	< 1	0.1	66.0	59.45	0	1.64	9.0	1.9	1.0	< 1

Chemical analyses of core samples in ppm (except Hg in ppb) from overburden samples in Area E N51 E61

APPENDIX C

HYDROLOGY

CONTENT

Hydrologic Terms
Table -1, Spring Date for the Colstrip Area
Table -2, Well Data for the Colstrip Area
Figure -1, Data-Point Numbering System

Hydrologic Terms

Aquifer - The body of porous material such as a formation, group of formations, or part of a formation of sufficient permeability and storage volume to transmit and yield ground water economically in usable quantities to wells and springs.

Artesian Condition - Ground water that is confined under pressure between relatively impermeable or signficantly less permeable material. Water levels in wells completed in artesian aquifers will rise above the top of the aquifer.

Hydraulic Conductivity - A measure of the ease of movement of ground water through aquifers and confining beds. It is expressed as the volume of water at the existing kinematic viscosity that will move through a porous medium in unit time under a unit hydraulic gradient through a unit area measured at right angles to the direction of flow. By Darcy's law, the volumetric flow rate Q through an Area A normal to the flow can be expressed as Q/A - K dh/ds, where dh/ds is the hydraulic gradient, the variation in potentiometric head, along the flow path ds. The coefficient K is the hydraulic conductivity and is the permeability of the aquifer multiplied by the specific weight of water divided by the fiscosity of water. The common units are gallons per day per square foot (gpd/ft^2), cubic feet per day per square foot ($ft^3/d/ft^2$ or ft/day) and cubic centimeters per second per square centimeter ($cm^3/s/cm^2$ or cm/sec).

Hydraulic Gradient - The variation in the potentiometric surface along a flow line; see hydraulic conductivity.

Natural Recharge - Infiltration of water under natural conditions from land surface to the saturated zone at the water table.

Permeability - The property of a porous medium which allows fluids to flow through it; see hydraulic conductivity. In much of the literature, the term permeability is taken to mean the same as hydraulic conductivity.

Potentiometric Surface - The imaginary surface connecting points to which water would rise in tightly-cased wells from a given point or an aquifer. Potentiometric is preferable to the term piezometric, which was used in the past.

Specific Capacity - The discharge from a well or spring, divided by the drawdown at that particular discharge at a particular time. Normally expressed in gallons per minute per foot (gpm/ft) at a specific discharge rate. This relationship is primarily a function of the aquifer transmissivity and/or the well efficiency. Specific capacity generally decreases at the pumping period increased because the drawdown continually increases with time as the cone of influence of the well expands.

Storage Coefficient - The ability of an aquifer to store water, expressed in numerical terms. It is defined as the volume of water released from or taken into storage per unit surface area of the aquifer by a unit change-in of head. In confined aquifers, the storage coefficient ranges from about 10^{-5} to 10^{-3}; in unconfined aquifers, the storage coefficient is virtually equal to the specific yield or drainable porosity; about 0.05 to 0.40.

Transmissivity - In general, the capacity of an aquifer to transmit water; equal to the horizontal hydraulic conductivity multiplied by the saturated thickness of the aquifer of (approximately) constant thickness. The normal units are: gallons per day per foot (gpd/ft); cubic feet per day per foot ($ft^3/d/ft$ or ft^2/dat; and cubic centimeters per second per foot ($cm^3/s/ft$ or cm^2/sec).

Water Table - Imaginery surface at atmospheric pressure within an unconfined aquifer. It is not bounded above by a confining bed.

TABLE -1

SPRING DATA FOR THE COLSTRIP AREA

Sheet 1 of 4

Location: See Figure D-1 for explanation of well-numbering system.
Altitude: Altitude of land surface at spring, estimated from U.S.G.S. 7.5 min. quad. topo. maps, accurate to 10 feet.
Specific conductance: Field electrical conductance of water, in micromhos per centimeter at 25°C.; "L" indicates laboratory conductance.
Aquifer: Interpretations by MBMG. Coded sources--RO+, more than 150 feet above Rosebud coal; RO, overburden, 0-150 feet above Rosebud coal; Sub Mc, unspecified aquifers stratigraphically below McKay coal.

Location	Altitude (feet)	Date examined	Specific conductance	Estimated discharge (gallons per minute)	Water use	Aquifer	Water analysis
2N. 38E. 03ABBB	3600	-	613	-	Stock	Rosebud coal	
2N. 38E. 03BAAA	3615	6-73	-	3	Stock	Rosebud coal	
2N. 38E. 03CCAD	3520	-	952	2	Stock	Rosebud coal	
2N. 38E. 10DCDC	3520	-	-	-	Stock	RO	
2N. 38E. 11ABBD	3520	-	-	-	Stock	RO	
2N. 38E. 11ADBC	3500	-	-	-	Stock	RO	
2N. 38E. 11DAAC	3480	-	-	-	Stock	RO	
2N. 38E. 11DCCA	3680	-	-	-	Stock	RO+	
2N. 38E. 12CADB	3460	6-73	-	6	Stock	Rosebud coal	
2N. 38E. 13ABBD	3400	-	-	3	Stock	Rosebud coal	
2N. 38E. 34ABBC	3630	7-73	-	1	Stock	RO+	
2N. 38E. 35ACAD	3700	-	-	-	Stock	RO+	
2N. 38E. 36BBBC	3670	7-73	-	-	Stock	RO+	
2N. 38E. 36DCDC	3760	7-73	-	0.5	Stock	RO+	
2N. 39E. 02CABB	3115	-	-	-	Stock	Sub Mc	
2N. 39E. 07BDCB	3380	7-73	-	-	Stock	Sub Mc	
2N. 39E. 08CBAD	3230	7-73	-	-	Stock	Sub Mc	
2N. 39E. 12CCCD	3140	-	-	-	Stock	Sub Mc	
2N. 39E. 14BDBB	3180	-	-	10	Stock	Alluvium	
2N. 39E. 18ABDC	3300	7-73	-	-	Stock	Sub Mc	
2N. 39E. 19DBDA	3435	7-73	-	-	Stock	Sub Mc	

Location	Altitude (feet)	Date examined	Specific conductance	Estimated discharge (gallons per minute)	Water use	Aquifer	Water analysis
2N. 39E. 24BDAB	3210	7-73	-	-	Stock	Sub Mc	
2N. 39E. 26DDAA	3295	-	-	-	Stock	Alluvium	
2N. 39E. 31ABAA	3500	10-72	3550	8	Stock	Rosebud coal	yes
2N. 39E. 31CBCD	3620	10-72	-	8	Stock	RO	
2N. 39E. 31CDCC	3620	10-72	-	-	Stock	RO+	
2N. 39E. 31CDCD	3620	10-72	-	-	Stock	RO+	
2N. 39E. 36CBAC	3395	-	-	-	Stock	McKay coal	
2N. 39E. 36CBBD	3390	-	-	-	Stock	McKay coal	
2N. 39E. 36CDDB	3400	7-73	-	0.5	Stock	McKay coal	
2N. 40E. 17CCBC	3255	-	-	-	Stock	Sub Mc	
2N. 40E. 17CDBA	3305	-	-	-	Stock	Sub Mc	
2N. 40E. 18DAAC	3235	-	-	-	Stock	Sub Mc	
2N. 40E. 18DADC	3240	10-72	3550	3.2	Stock	Sub Mc	yes
2N. 40E. 28CCBB	3420	7-75	-	5	Stock	Alluvium	
2N. 40E. 32BBAA	3380	-	-	-	Stock	Rosebud coal	
2N. 40E. 33CCDD	3415	-	-	-	Stock	Alluvium	
2N. 41E. 13BBCD	3200	-	-	-	Stock	Alluvium	
2N. 41E. 17ADAD	3120	10-73	2798L	-	Stock	Sub Mc	yes
2N. 42E. 30CCCA	3225	-	-	-	Stock	Rosebud clinker	
2N. 42E. 31CBDC	3160	-	-	-	Stock	Alluvium	
1N. 38E. 02DADD	3920	-	-	-	Stock	RO+	
1N. 38E. 03AACC	3710	-	-	-	Stock	RO+	
1N. 38E. 03ACDC	3660	8-73	4320	-	Stock	RO+	
1N. 38E. 03ADCC	3680	-	-	-	Stock	RO+	
1N. 38E. 10BBDC	3540	-	2050	1	Stock	RO	
1N. 38E. 11CCDD	3660	8-73	-	-	Stock	RO+	
1N. 38E. 11DBBC	3743	8-73	5840	0.1	Stock	RO+	

Location	Altitude (feet)	Date examined	Specific conductance	Estimated discharge (gallons per minute)	Water use	Aquifer	Water analysis
1N. 38E. 12CDCA	3850	-	-	-	Stock	RO+	
1N. 38E. 13AADA	3830	8-73	1860	0.5	Stock	RO+	
1N. 38E. 13BABB	3820	-	-	-	Stock	RO+	
1N. 38E. 13BCBA	3755	-	-	-	Stock	RO+	
1N. 38E. 14CBCB	3540	-	-	-	Stock	RO+	
1N. 38E. 15BBDA	3550	8-73	2830L	0.1	Stock	Rosebud coal	yes
1N. 38E. 15BCCD	3415	8-73	7320	-	Stock	Sub Mc	
1N. 38E. 15DAAD	3460	-	-	-	Stock	RO	
1N. 39E. 06ADDA	3690	7-73	-	-	Stock	RO+	
1N. 39E. 08CDDA	4160	7-73	-	-	Stock	RO+	
1N. 39E. 09DDAA	3920	7-73	-	-	Stock	RO+	
1N. 39E. 10BABB	3790	-	-	-	Stock	RO+	
1N. 39E. 11BBDD	3940	-	-	-	Stock	RO+	
1N. 39E. 14BBAB	3820	10-73	-	-	Stock	RO+	
1N. 39E. 17AACB	4260	10-73	-	-	Stock	RO+	
1N. 39E. 18ADCC	4175	10-73	-	-	Stock	RO+	
1N. 39E. 18ADDD	4330	10-73	-	-	Stock	RO+	
1N. 39E. 18BDBC	4020	-	-	-	Stock	RO+	
1N. 39E. 18BDCB	4000	8-73	-	2	Stock	RO+	
1N. 39E. 23CCBB	3990	-	-	-	Stock	RO+	
1N. 39E. 24ABCC	3780	-	-	-	Stock	RO+	
1N. 40E. 02BABD	3440	7-73	2930L	0.3	Stock	Rosebud coal	yes
1N. 40E. 02BBDD	3450	7-73	-	-	Stock	Rosebud coal	
1N. 40E. 02BDAB	3450	7-73	-	-	Stock	Rosebud coal	
1N. 40E. 04CAAA	3435	-	-	-	Stock	Rosebud coal	
1N. 40E. 19DCCD	3630	9-73	2090L	1	Stock	RO+	yes
1N. 40E. 20DADC	3515	9-73	-	0.3	Stock	RO	
1N. 40E. 27DCDD	3350	-	-	-	Stock	RO	
1N. 40E. 30ABBC	3610	9-73	-	3	Stock	RO+	

TABLE -1

Location	Altitude (feet)	Date examined	Specific conductance	Estimated discharge (gallons per minute)	Water use	Aquifer	Water analysis
1N. 40E. 30ACDC	3610	9-73	-	3	Stock	RO+	
1N. 40E. 31DBDA	3610	7-73	-	1	Stock	RO+	
1N. 40E. 32ADDB	3490	-	-	-	Stock	RO+	
1N. 41E. 24CCAA	3130	-	-	-	Stock	Alluvium	
1S. 40E. 03BBAD	3510	-	-	-	Stock	RO+	
1S. 40E. 06BBDB	3890	9-73	1640	0.2	Stock	RO+	yes
1S. 40E. 07CBCD	3675	9-73	-	0.2	Stock	RO+	
1S. 40E. 08AADB	3600	9-73	2400	2	Stock	RO+	yes
1S. 40E. 09DA0C	3475	-	-	-	Stock	RO+	
1S. 40E. 12DDDA	3480	7-73	692L	0.5	Stock	RO+	yes

WATER-WELL DATA FOR THE COLSTRIP AREA, SOUTHEASTERN MONTANA

Location: See Figure D-1 for explanation of well-numbering system.
Altitude: Altitude of land surface at well, estimated from U.S.G.S. 7.5 min. quad. topo. maps; accurate to 10 feet.
Depth to water: Depths to nearest 0.1 foot measured; depths to nearest 1.0 foot reported; "F" indicates flowing well.
Specific conductance: Field electrical conductance of water, in micromhos per centimeter at 25°C.; "L" indicates laboratory conductance.
Aquifer: Interpretations by MBMG. Coded sources--RO+, more than 150 feet above Rosebud coal; RO, overburden, 0-150 feet above Rosebud coal; Sub Mc, unspecified aquifers stratigraphically below McKay coal.

Location	Altitude (feet)	Well depth (feet)	Depth to water (feet)	Date examined	Specific conductance	Temperature (°C.)	Water use	Aquifer	Water analysis
2N. 38E. 15ACDA	3540	-	-	7-73	1840	-	Stock	Sub Mc	
2N. 38E. 15CCDC	3500	-	-	7-73	1232L	-	Stock	Sub Mc	yes
2N. 38E. 24BCBC	3530	-	-	-	1290	-	Stock	Alluvium	
2N. 38E. 25CDDC	3640	-	150	-	-	-	Stock	Rosebud coal	
2N. 38E. 26AABA	3650	226	166.8	10-73	-	-	Stock	Sub Mc	
2N. 38E. 36CDBD	3766	-	60	-	-	-	Stock	RO+	
2N. 39E. 03CDBB	3195	113	61.0	9-73	-	-	Stock	Sub Mc	
2N. 39E. 05BCBA	3205	57	-	9-73	2400	11.0	Stock	Sub Mc	yes
2N. 39E. 05DDDC	3170	16	15.2	9-73	6630L	13.3	Stock	Alluvium or Sub Mc	yes
2N. 39E. 06CBBB	3320	-	-	-	-	-	Stock	Sub Mc	
2N. 39E. 08AABB	3170	-	-	-	-	-	Stock	Sub Mc	
2N. 39E. 10BBCA	3245	130	75	-	-	-	Stock	Sub Mc	
2N. 39E. $12CCC_1$	3160	555	-	11-72	1200	13.5	House	Tullock	yes
2N. 39E. $12CCC_2$	3150	71	35	-	-	-	Stock	Sub Mc	
2N. 39E. 12CCDB	3130	20	17	-	-	-	Stock	Alluvium	
2N. 39E. 14BDDB	3180	240	-	7-75	3150	-	House	Sub Mc	
2N. 39E. 16ACDD	3260	100	35	-	-	-	Stock	Sub Mc	
2N. 39E. 17DCAA	3320	-	-	8-75	-	-	Stock	Sub Mc	
2N. 39E. 19CACB	3468	-	-	-	-	-	Stock	Unknown	
2N. 39E. 20DBCB	3457	-	-	8-75	-	-	Stock	Unknown	
2N. 39E. 23CAAB	3350	-	98.7	7-73	1450	27.0	Stock	Sub Mc	yes
2N. 39E. 24CDAB	3250	140	50	7-73	3030L	-	Stock	Sub Mc	yes
2N. 39E. 24CDDD	3240	46	18.1	7-73	-	-	Unused	Sub Mc	
2N. 39E. 25ACDC	3280	136	58	7-73	5060L	-	Stock	Sub Mc	yes
2N. 39E. 27CCCC	3430	262	127.8	7-73	-	-	Stock	Sub Mc	
2N. 39E. 28CABD	3375	-	-	8-75	-	-	Unused	Unknown	
2N. 39E. 29BCCC	3456	-	-	8-75	-	-	-	Unknown	

TABLE -2

Sheet 2 of 6

Location	Altitude (feet)	Well depth (feet)	Depth to water (feet)	Date examined	Specific conductance	Temperature (°C.)	Water use	Aquifer	Water analysis
2N. 39E. 30CBAA	3555	-	-	-	-	-	Stock	Unknown	
2N. 39E. 31CBAA	3550	128	35.9	7-75	-	-	Stock	Rosebud coal or RO	
2N. 39E. 31CCBA	3625	220	73.1	7-75	-	-	Stock	Rosebud coal	
2N. 39E. 32CDCD	3520	-	-	7-73	3500	12.5	Stock	Unknown	yes
2N. 39E. 34ADBB	3435	60	27	11-72	2940L	-	House	Rosebud coal	yes
2N. 39E. 34DADB	3470	80	26.9	7-73	2050L	16.0	Stock	Rosebud coal	yes
2N. 40E. 01AAAA	3145	117	93	8-75	-	-	Stock	Tullock	
2N. 40E. 02DACB	3205	69	29.3	8-75	-	-	Unused	Sub Mc	
2N. 40E. 04BBAA	3270	84	30	-	-	-	Stock	Sub Mc	
2N. 40E. 06ABAB	3190	86	70	-	-	-	Stock	Sub Mc	
2N. 40E. 06ABAC	3200	143	84	-	-	-	Stock	Sub Mc	
2N. 40E. 06ABBA	3190		40	-	2400	-	House	Sub Mc	
2N. 40E. 06CBCB	3160	104	84	7-73	3000	10.5	Stock	Sub Mc	yes
2N. 40E. 07BDCC	3210	128	80	7-73	-	-	Stock	Sub Mc	
2N. 40E. 10BBCD	3282	210	145	-	-	-	Stock	Sub Mc	
2N. 40E. 11AABA	3241	130	60	-	-	-	Stock	Sub Mc	
2N. 40E. 12AAAB	3260	165	30	-	-	-	House	Sub Mc	
2N. 40E. 17AACA	3440	184	165	-	-	-	Stock	Sub Mc	
2N. 40E. 17ABDD	3480	185	80	-	-	-	Stock	Sub Mc	
2N. 40E. 24DBDC	3220	85	60	-	-	-	House	Sub Mc	
2N. 40E. 24DCBA	3220	30	22	-	-	-	Stock	Alluvium	
2N. 40E. 25BABA	3245	80	60	-	-	-	Stock	Sub Mc	
2N. 40E. 26BADB	3274	-	-	-	-	-	Stock	Sub Mc	
2N. 40E. 28AADD	3370	146	75.7	7-75	3510	12.0	Stock	Sub Mc	
2N. 40E. 29CCDC	3380	-	F	7-75	2820	16.0	Stock	Sub Mc	
2N. 40E. 30BAAD	3275	246	72	7-73	3500	14.0	Stock	Sub Mc	yes
2N. 40E. 31DCCD	3530	165	113.6	11-72	1750	13.0	Stock	Rosebud coal and McKay coal	yes
2N. 40E. 32BBAB	3390	-	-	7-73	950	-	House	Sub Mc	yes
2N. 40E. 32BBDA	3430	67	23.3	7-73	-	-	Unused	Rosebud clinker	
2N. 40E. 33ADDD	3360	140	100	-	-	-	Stock	Sub Mc	
2N. 40E. 35DDCD	3425	250	148.2	7-73	2800	11.5	Stock	Sub Mc	yes
2N. 41E. 01DBBA	3140	-	61.7	8-73	878L	11.5	Stock	Sub Mc	yes
2N. 41E. 02ACDC	3160	10	3	8-73	-	-	Stock	Alluvium	
2N. 41E. 02CBBA	3170	220	-	11-72	3290L	-	House	Sub Mc	yes
2N. 41E. 08ACCD	3182	-	-	10-73	-	-	Stock	Sub Mc	
2N. 41E. 10BCBC	3175	150	100	7-73	1825	13.0	Stock	Sub Mc	yes
2N. 41E. 12CCAD	3178	-	-	-	-	-	Stock	Sub Mc	

TABLE -2

Sheet 3 of 6

Location	Altitude (feet)	Well depth (feet)	Depth to water (feet)	Date examined	Specific conductance	Temperature (°C.)	Water use	Aquifer	Water analysis
2N. 41E. 17ADAA	3121	110	-	10-73	2390L	12.0	House	Sub Mc	yes
2N. 41E. 20DDCO	3224	70	22.6	8-75	-	-	Stock	Sub Mc	
2N. 41E. 21CADA	3165	122	29.7	11-72	3460L	10.0	Public	Sub Mc	yes
2N. 41E. 21[illegible]D	3240	120	40.3	8-75	3830	11.0	Stock	Sub Mc	
2N. 41E. 22BAAB	3260	68	57	-	-	-	Stock	Sub Mc	
2N. 41E. 24CAAC	3450	27	23.6	7-73	-	-	Stock	RO	
2N. 41E. 24CABA	3460	18	-	7-73	-	-	House	RO	
2N. 41E. 27CCBC	3219	-	-	-	-	-	Stock	Alluvium or Sub Mc	
2N. 41E. 30DDAA	3360	-	-	10-73	3076L	13.0	Stock	Unknown	yes
2N. 41E. 32DABB	3420	300	140	-	-	-	Stock	Sub Mc	
2N. 41E. 33DAAA	3270	519	315	-	-	-	Public	Tullock	
2N. 41E. 33DAAD$_1$	3270	1520	60	-	-	-	Public	Hell Creek	
2N. 41E. 33DAAD$_2$	3270	596	203	-	-	-	Public	Tullock	
2N. 41E. 34BADC	3120	9336	-	-	-	-	Public	Madison	
2N. 41E. 34BCBB	3260	614	-	-	-	-	Public	Tullock	
2N. 42E. 04DACA	3003	102	60	8-73	2058L	11.5	Stock	Sub Mc	yes
2N. 42E. 05CABB	3077	-	56.5	8-73	2072L	11.0	Stock	Sub Mc	yes
2N. 42E. 06CBDC	3140	120	87.3	11-72	1950	12.0	Stock	Sub Mc	yes
2N. 42E. 07DCAD	3135	-	-	-	-	-	-	Sub Mc	
2N. 42E. 09CCBA	3087	-	-	-	-	-	-	Sub Mc	
2N. 42E. 20CDAD	3195	115	-	11-72	-	-	Stock	Sub Mc	
2N. 42E. 30CDCB	3245	200	-	-	-	-	Stock	Sub Mc	
2N. 42E. 32DBCC	3130	100	-	-	-	-	Stock	Sub Mc	
1N. 38E. 10ADCA	3679	-	-	-	-	-	Stock	RO+	
1N. 38E. 11BBCB	3740	-	34.7	8-73	5040	-	Stock	RO+	
1N. 38E. 13CDCC	3660	-	-	-	-	-	Stock	RO+	
1N. 39E. 01BBBA$_1$	3460	84	30	-	-	-	Stock	Sub Mc	
1N. 39E. 01BBBA$_2$	3476	96	39.9	7-73	-	-	Stock	Sub Mc	
1N. 39E. 02BBBB	3535	-	-	-	-	-	Stock	Unknown	
1N. 39E. 04AABC	3537	-	-	-	-	-	Stock	Unknown	
1N. 39E. 04DBCC	3643	-	-	-	-	-	Stock	Unknown	
1N. 39E. 05CBBA	3690	300	-	-	3000	12.0	Stock	RO+	yes
1N. 39E. 05CBBB	3745	-	-	-	-	-	Stock	Unknown	
1N. 39E. 10BBBB	3770	-	-	-	-	-	Stock	Unknown	
1N. 39E. 11ADAD	3860	-	-	-	-	11.0	Stock	Unknown	
1N. 39E. 12CCCC	3735	-	-	-	-	9.0	Stock	Unknown	
1N. 39E. 15BDAD	3910	-	-	-	-	-	Stock	Unknown	

TABLE -2 Sheet 4 of 6

Location	Altitude (feet)	Well depth (feet)	Depth to water (feet)	Date examined	Specific conductance	Temperature (°C.)	Water use	Aquifer	Water analysis
1N. 39E. 23CAAA	3890	-	-	-	-	-	Stock	Unknown	
1N. 39E. 24BBBC	3826	122	62	9-73	2423L	12.0	Stock	RO+	yes
1N. 39E. 25ABDC	3578	375	-	-	-	-	Stock	RO+	
1N. 40E. 01CCCD	3418	80	34.1	7-73	-	-	Stock	RO	
1N. 40E. 02BBDC	3510	44	34.1	7-73	520	9.0	House	RO	yes
1N. 40E. 02CDCC	3512	100	42.2	10-73	1250L	11.0	Stock	Rosebud coal	yes
1N. 40E. 04DA00	3505	-	-	-	-	-	Stock	Unknown	
1N. 40E. 04DBBA	3440	200	75	-	-	-	Stock	Sub Mc	
1N. 40E. 05CCCB	3530	115	85.3	-	-	-	Stock	Rosebud coal or RO	
1N. 40E. 06ABBB	3520	128	40	-	-	-	Stock	Rosebud coal and McKay coal	
1N. 40E. 07BCBB	3720	143	84.3	-	-	-	Stock	RO+	
1N. 40E. 10DAAB	3470	132	50	-	-	-	Stock	McKay coal	
1N. 40E. 11ABBB	3558	-	-	10-73	-	-	-	Unknown	
1N. 40E. 12CBAA	3400	40	35.4	9-73	1700	10.5	Stock	Alluvium	yes
1N. 40E. 13ABAA	3426	-	-	10-73	2298L	11.0	Stock	Unknown	yes
1N. 40E. 14BBBB$_1$	3438	-	-	10-73	1542L	10.0	Stock	Unknown	yes
1N. 40E. 14BBBB$_2$	3438	-	-	10-73	1344L	-	House	Unknown	yes
1N. 40E. 15BBCB	3480	-	-	9-73	1520L	11.0	Stock	Unknown	yes
1N. 40E. 16DBAA	3520	-	42.8	9-73	-	-	Unused	Rosebud coal or RO	
1N. 40E. 17BAAA	3560	-	-	-	-	-	Stock	Unknown	
1N. 40E. 18ABBB	3640	-	-	7-73	-	-	House	Unknown	
1N. 40E. 18BABA	3630	-	-	-	-	-	Stock	Unknown	
1N. 40E. 18DDDC	3654	50	23	9-73	-	-	Unused	RO+	
1N. 40E. 21AAAD	3548	120	106.4	9-73	-	-	Unused	Rosebud coal	
1N. 40E. 23BDDB	3420	100	30	-	-	-	Stock	Rosebud coal	
1N. 40E. 24CACB	3380	66	35.3	9-73	-	-	Stock	Rosebud coal or RO	
1N. 40E. 26CABB	3423	-	-	-	-	-	Stock	Unknown	
1N. 40E. 28ADDD	3415	74	35.4	9-73	-	-	Stock	RO	
1N. 40E. 29ACBB	3550	232	80	9-73	2756L	10.5	Stock	Sub Mc	yes
1N. 40E. 34DCBB	3595	-	-	-	-	-	Stock	Unknown	
1N. 40E. 35CAAD	3298	-	-	-	-	-	Stock	Unknown	
1N. 40E. 36BACD	3440	104	85	9-73	-	-	Stock	RO	
1N. 41E. 02DACC	3330	141	76	-	-	-	Stock	Rosebud coal and McKay coal	
1N. 41E. 03BBBB	3240	55	45	-	-	-	Stock	McKay coal	
1N. 41E. 03CDDD	3330	86	67.4	8-73	1600	11.5	Stock	RO	yes
1N. 41E. 04DDBA	3330	-	-	-	-	-	Stock	Unknown	
1N. 41E. 06ACAB	3470	-	-	-	-	-	Stock	Unknown	
1N. 41E. 06DDDB	3365	-	-	-	-	-	Stock	Unknown	
1N. 41E. 07DBBA	3360	125	100	10-73	1160L	11.0	Stock	Sub Mc	yes

TABLE -2 Sheet 5 of 6

Location	Altitude (feet)	Well depth (feet)	Depth to water (feet)	Date examined	Specific conductance	Temperature (°C.)	Water use	Aquifer	Water analysis
1N. 41E. 08BBDB	3320	50	-	-	-	-	Stock	Alluvium	
1N. 41E. 08DBDC	3320	389	-	3-73	2610L	13.0	House	Sub Mc	yes
1N. 41E. 08BBDD	3320	50	-	-	-	-	Stock	Alluvium	
1N. 41E. 08CBAB$_1$	3357	100	-	10-73	776L	11.0	Stock	Rosebud coal	yes
1N. 41E. 08CBAB$_2$	3345	18	-	10-73	-	-	Unused	Alluvium	
1N. 41E. 12CBDB	3160	51+	-	8-73	3000	15.5	Stock	Unknown	yes
1N. 41E. 13CCCD	3290	200	108.9	11-72	2150	16.0	Irrigation	Sub Mc	yes
1N. 41E. 17CCBB	3190	-	-	-	-	-	Stock	Unknown	
1N. 41E. 23CCDC	3230	74+	44.9	8-73	2544L	19.0	Industrial	Sub Mc	yes
1N. 41E. 23CCAD	3260	300	190	-70		-	House	Sub Mc	
1N. 41E. 24DDBB	3150	30+	13.8	8-73	-	-	Stock	Sub Mc	
1N. 41E. 25DDBB	3085	60+	38.3	8-73	-	-	Stock	Sub Mc	
1N. 41E. 26BCAB	3190	195	23.5	8-73	-	-	Unused	Sub Mc	
1N. 41E. 30BBCD	3328	90	30	9-73	-	-	Stock	Rosebud coal	
1N. 41E. 31AADA	3255	153	83.3	9-73	-	-	Stock	Sub Mc	
1N. 41E. 33BCCB	3190	65	22.0	9-73	-	-	Stock	Sub Mc	
1N. 42E. 07CBBD	3260	940	-	2-72	-	-	Fire	Hell Creek	
1N. 42E. 19DBBA	3128	67	22.7	8-73	1600	11.0	Stock	McKay coal	yes
1N. 42E. 26BDDC	3010	53	17.8	8-73	1906L	10.0	Stock	Sub Mc	yes
1N. 42E. 31BBBC	3090	-	-	8-73	-	-	Stock	Sub Mc	
1N. 42E. 32DADD	2990	80	33.7	8-73	-	-	Stock	Sub Mc	
1N. 42E. 33ADBC	2970	42	24.2	9-72	3200	10.0	Stock	Sub Mc	yes
1N. 42E. 33BDCA	2990	91	57	8-73	-	-	Stock	Sub Mc	
1S. 40E. 02CACC	3415	-	-	-	-	-	Stock	Unknown	
1S. 40E. 03BACD	3500	-	-	-	-	-	Stock	Unknown	
1S. 40E. 05CDAD	3660	-	-	9-73	-	-	Stock	RO+	
1S. 40E. 06DADA	3757	150	120	9-73	-	-	Stock	RO+	
1S. 40E. 07DADA	3580	420	220	7-73	2906L	13.0	Stock	RO	yes
1S. 40E. 09DADB	3485	44	41.5	7-73	-	-	Stock	RO+	
1S. 40E. 14DCBD	3327	62	50.4	9-73	-	-	Stock	RO+	
1S. 40E. 16DABD	3410	65	60	7-73	-	-	Stock	RO+	
1S. 41E. 01DBBA	3105	54	38	9-73	-	-	Stock	Sub Mc	
1S. 41E. 02AABB	3150	81	26.5	7-73	2348L	-	Stock	Sub Mc	yes
1S. 41E. 05CADC	3220	150	105	-	-	-	Stock	Sub Mc	
1S. 41E. 06AAAC	3250	-	-	-	-	-	Stock	Unknown	
1S. 41E. 09CABC	3165	-	-	-	-	-	Stock	Unknown	
1S. 41E. 17DBCC	3130	-	-	-	-	-	Stock	Unknown	

TABLE -2 Sheet 6 of 6

Location	Altitude (feet)	Well depth (feet)	Depth to water (feet)	Date examined	Specific conductance	Temperature (ºC.)	Water use	Aquifer	Water analysis
1S. 41E. 13DCCB	3060	60	14	-	-	-	Stock	Sub Mc	
1S. 41E. 14BDDD	3060	80	14	-	-	-	House	Sub Mc	
1S. 41E. 14CCCB	3050	76	26.5	7-73	-	-	Stock	Sub Mc	
1S. 41E. 15DDCA	3091	71	-	-	-	-	Stock	Sub Mc	
1S. 41E. 17DAAD	3169	45	24	-	2450	10.5	Stock	Sub Mc	yes
1S. 42E. 03BBDC	2290	-	-	-	-	-	-	Alluvium or Sub Mc	
1S. 42E. 04DCA$_1$	3010	38	26.6	8-73	5250	11.5	Irrigation	Alluvium	yes
1S. 42E. 04DCA$_2$	3010	40	22.2	8-73	4500	13.0	Irrigation	Alluvium	yes
1S. 42E. 05ADBB	3070	-	-	-	-	-	-	Sub Mc	
1S. 42E. 07AACB	3040	-	-	-	-	-	-	Alluvium or Sub Mc	
1S. 42E. 08DAAC	3055	-	-	-	-	-	-	Sub Mc	
1S. 42E. 09ACDC	3040	-	-	-	-	-	-	Sub Mc	
1S. 42E. 16ACCA	3090	-	-	-	-	-	-	Sub Mc	
1S. 42E. 17DDDB	3196	-	-	-	-	-	-	Sub Mc	

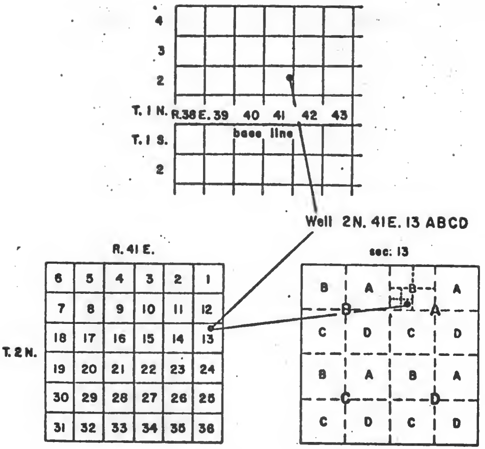

FIGURE -1

DATA - POINT NUMBERING SYSTEM

APPENDIX D-1

DETAILED DESCRIPTION OF COMMUNITY TYPES IN AREAS A AND E

Plant Community Descriptions:

Taken from: Ecological Consulting Service 1975. Western Energy Vegetation. Production, Condition and Community Typing. Mining areas A, B and E. Project 107.23.A. Helena, Montana. 38 pp.

Grassland Communities:

Agropyron smithii-Bromus spp.-Poa. spp. (111.1)

This community was present on mesic bottomlands of heavy soils. The SCS range site for this type was classed as overflow (USDA 1971), which is characterized by low mesic bottomland.

Dominant grass species in this community were western wheatgrass (Agropyron smithii), Japanese chess (Bromus japonicus), Kentucky bluegrass (Poa pratensis), and green needlegrass (Stipa viridula). The type was similar to Plant Community 220.

Agropyron smithii-Koeleria cristata-Carex filifolia (111.2)

This plant community occurred adjacent to the community previously discussed but at slightly higher elevations. Gradients were not much different as it usually was found on low benches, but sites were slightly more xeric than at sites occupied by Plant Community 111.1. At times it appeared to be an ecotone between Plant Communities 111.1 and 111.3

Dominant grass species found in this community were western wheatgrass, Japanese chess, junegrass (Koeleria cristata), green needlegrass, cheatgrass (Bromus tectorum), and threadleaf sedge (Carex filifolia). Western wheatgrass was found at all sites. Green needlegrass occurred in transects conducted closest to Plant Community 111.1. Junegrass and blue grama were found in transects in closer proximity to Plant Community 111.3

Stipa comata-Carex filifolia-Koeleria cristata (111.3)

Upper benches, knolls, and ridges not dominated by shrubs or timber were sites where this plant community occurred. This was a common plant community and was rather widespread in the areas of study. Sindelar (1972) described a similar range type. This community would probably be more extensive if not for past disturbance. It generally occurred at gradients above that of Plant Community 111.2 in more xeric soils.

The three most common grasses were needle-and-thread (Stipa comata), threadleaf sedge, and junegrass. Needle-and-thread was found in every transect. Japanese chess, cheatgrass, and red three-awn (Aristida longiseta) were also found in this plant community.

Calamovilfa longifolia-Andropogon spp. (111.4)

This community occurred as localized patches on knolls and on footslopes of ridges. It was generally found in close association with sandy soils and appeared to occur on any exposure near the top of knolls or ridges.

Prairie sand reedgrass (Calamovilfa longifolia) and little bluestem (Andropogon scoparius) were dominant grasses. Big bluestem (Andropogon gerardii) occurred at some sites along with junegrass and needle-and-thread. Some sites tended to be dominated more by little bluestem and others by prairie sand reedgrass.

Bromus tectorum (111.5)

This community occurred as isolated sites wherever the other natural types were disturbed or severely overgrazed. It occurred more often in Plant Communities 111.2 and 111.3 as well as in shrub-grassland communities such as Plant Community 213. It was often found on south-facing slopes that "green up" early in the spring and hence are sought out and overgrazed by livestock. It also occurred near windmills where livestock gather for water. It could occur in any natural plant community. It was characterized by dense stands of cheatgrass.

Shrub-grassland Communities:

Artemisia tridentata-Koeleria cristata-Agropyron spicatum (211)

Upper slopes and benches were common sites where this plant community was found. Soils of this community were fine and clayey. Often times this plant community appeared to be overgrazed.

Big sagebrush (Artemisia tridentata) was the dominant shrub and appeared to be very scrubby. Common grasses were junegrass, which appeared in every transect, and bluebunch wheatgrass (Agropyron spicatum). Western wheatgrass, Japanese chess, blue grama, and sandberg bluegrass (Poa secunda) were other common grasses.

Artemisia cana-Agropyron smithii-Stipi viridula-Poa spp. (212.1)

This plant community characteristically occupied the moist drainage channels in the areas of study and was typically associated with the moist, coarser soils of alluvial overflow sites (Parker 1970). It was generally found in mesic draws and coulees. Sindelar (1972) described a similar range type. It was usually bordered by Plant Communities 111.1 or 212.2.

Silver sagebrush was the dominant shrub and occurred in very dense stands. Common grasses were western wheatgrass, green needlegrass, and bluegrasses (Poa spp.). At times, Japanese chess occurred also.

Artemisia cana-Agropyron smithii-Stipi viridula-Bromus spp. (212.2)

This plant community was found on lower benches adjacent to swales and coulees inhabited by Plant Community 212.1. The SCS range site classification was silty compared to overflow for Plant Community 212.1 (USDA 1971). The dominant shrub in this community was silver sagebrush, but was found in sparse stands in comparison to the dense stands in

Plant Community 212.1. Grasses indigenous to this type were similar to Plant Community 212.1 and consisted of western wheatgrass, green needlegrass, cheatgrass, and Japanese chess.

Rhus trilobata-Stipa comata-Agropyron smithii (213)

This plant community occurred often near and within stands of ponderosa pine (Pinus ponderosa) (Martin 1973). At other sites it was found as a distinct shrub-grassland community with no close association with stands of ponderosa pine. It was found in sandy soils on ridges, knolls, or south-facing slopes. Other sites where this community was found was near sandstone outcrops or on flat benches surrounded by ponderosa pine. Since it was often found on south-facing slopes, cheatgrass was quite common at these sites, again due to the early "green up" and associated overgrazing by livestock.

Skunkbush sumac (Rhus trilobata) was the most dominant shrub. Common grasses were western wheatgrass, needle-and-thread, junegrass, prairie sand reedgrass, bluebunch wheatgrass, and cheatgrass.

Chrysothamnus nauseosus-Agropyron spicatum-Oryzopsis hymenoides (214)

This community generally occurred on isolated knobs and knolls in conjunction with unstable clay gumbos. It also occurred on very steep gumbo slopes. This type was not very extensive in size but could be found throughout the areas of study. The SCS range site was determined to be a dense clay site (USDA 1971). Vegetation was very sparse.

Rubber rabbitbrush (Chrysothamnus nauseosus) was the most common shrub. Other shrubs that occurred in this type was shadscale saltbush (Atriplex confertifolia), broom snakeweed, and big sagebrush. Bluebunch wheatgrass and Indian ricegrass (Oryzopsis hymenoides) were the two most common grasses. Western wheatgrass was also found at some sites.

Timber-grassland Communities:

Acer negundo-Fraxinus pennsylvanica-Poa spp.-Agropyron smithii (220)

This plant community occurred along creek bottoms. The major creek in the area of study was the upper east fork of Armell's Creek. The overstory consisted of box elder (Acer negundo) and green ash (Fraxinus pennsylvanica). A few plains cottonwoods (Populus deltoides) could also be found. The understory of this community was very similar to Plant Community 111.1. Common grasses consisted of Kentucky bluegrass and western wheatgrass. At other sites, shrubs such as prairie rose (Rosa arkansana) and snowberry (Symphoricarpos spp.) occurred in the understory. This type was limited in extent in the area of study, and most of it had been disturbed by the extensive construction of new mining facilities that border the east fork of Armell's Creek.

Pinus ponderosa-Agropyron spicatum (351)

This plant community occurred at higher elevations along ridges and sandstone outcrops within the study area. At some sites this community occurred along coulees leading away from the ridges. The soils were classed as thin-hilly by SCS criteria (USDA 1971). The overstory aspect of the type varied from a near closed canopy "woods" to a very open canopy "savanna" of scattered trees. The understory varied inversely with the overhead canopy in regard to cover. In areas of open canopy the understory was well developed, and in areas of closed canopy the understory was generally sparse and poorly developed.

Kuchler (1964) described the entire Colstrip vicinity as an eastern ponderosa pine vegetation formation. Pfister, et al. (1973) described the area as a Pinus ponderosa/Agropyron spicatum habitat type within a Pinus ponderosa series.

Ponderosa pine was the most common tree. Rocky Mountain juniper (Juniperus scopulorum) occurred in limited fashion. Common grasses consisted of bluebunch wheatgrass, threadleaf sedge, needle-and-thread, and junegrass. Skunkbush sumac was a common shrub.

Pinus ponderosa-Juniperus scopulorum-Agropyron spicatum (352)

This community occurred on ridges at high elevations. It was very limited in extent in the areas of study and was usually found on steep north-facing slopes.

Rocky Mountain juniper was the most common tree. Ponderosa pine occurred in limited fashion. Like Plant Community 351, the understory varied from barren areas to quite shrubby areas inversely dependent on the overstory canopy. This plant community was generally more open in regard to overstory canopy than Plant Community 351. The most common grass was bluebunch wheatgrass. Other grass species included Japanese chess, sideoats grama (Bouteloua curtipendula), and plains muhly (Muhlenbergia cuspidata). Common shrubs were big sagebrush, skunkbush sumac, and rubber rabbitbrush.

Non-natural Plant Communities:

Agricultural (530)

Sites disturbed by man for agricultural purposes, such as fields of winter wheat, its associated fallow and alfalfa, were classed as agricultural plant communities.

Stock Ponds (543)

These sites consisted of stock watering ponds created by the damming of drainages for the purpose of providing water for domestic livestock.

Disturbed Grassland (651)

This plant community occurred wherever man disturbed the natural plant communities in the past by plowing. These sites varied in grass species present due to the successional response over the number of years since disturbance. Recent sites were dominated by crested wheatgrass (Agropyron cristatum). Native grasses such as western wheatgrass and needle-and-thread occurred on apparently older sites. Invading annuals such as cheatgrass and Japanese chess were also found at these sites.

Roadways (652)

This type consisted of county roads, highways, railroads, and their associated borrow areas.

Residential Areas (653)

These sites were very limited in extent and consisted of farm and ranch yards, corrals and other disturbed areas used to park farm equipment.

APPENDIX D-2

DESCRIPTION OF ACREAGES AND PRODUCTIVITY OF BURLINGTON-NORTHERN CROPLANDS IN AREA A AND PRODUCTIVITY DATA FOR COMMUNITY TYPES IN AREA E

BURLINGTON NORTHERN

AGRICULTURAL RESOURCES
DEPARTMENT

P.O. Box 579
Miles City, Montana 59301
Telephone (406) 232-1274

March 23, 1977

Mr. Dana C. Schmidt
c/o Olson-Elliott & Associates
P. O. Box 1209
349 Last Chance Gulch
Helena, Montana 59601

Re: Your letter dated March 16, 1977

Dear Mr. Schmidt:

Here is the information you requested in the above referenced letter.

Section 5, Township 1 North, Range 41 East, MPM

1976: 94.3 ac. winter wheat, average yield-32.0 bu/ac.
70.9 ac. alfalfa, average yield-1.7 ton/ac.
14.0 ac. alfalfa-grass mix, average yield-.74 ton/ac.
76.9 ac. summer fallow

1975: 76.9 ac. winter wheat, average yield-30.6 bu/ac.
98.1 ac. alfalfa, average yield-1.9 ton/ac.
14.0 ac. alfalfa-grass mix, cash leased, no yield data
94.3 ac. summer fallow

1974: 94.3 ac. winter wheat, average yield-35.4 bu/ac.
98.1 ac. alfalfa, average yield-1.2 ton/ac.
14.0 ac. alfalfa-grass hay, cash leased
76.9 ac. summer fallow

1973: 76.9 ac. winter wheat, average yield-28.8 bu/ac.
15.0 ac. oats, average yield-26.6 bu/ac.
104.7 ac. oats & alfalfa hay, average yield-.95 ton/ac.
23.5 ac. alfalfa grass hay, cash leased
94.3 ac. summer fallow

1972: 167.8 ac. winter wheat, average yield-20.3 bu/ac.
76.6 ac. oats & alfalfa, no yield data (new seeding)
23.5 ac. grass, cash leased
76.9 ac. summer fallow

West ½ Section 4, Township 1 North, Range 41 East, MPM

1974: 52.3 ac. winter wheat, average yield-36.4 bu/ac.
48.4 ac. summer fallow

1973: 81.3 ac. winter wheat, average yield-37.2 bu/ac.
78.8 ac. summer fallow

1972: 82.6 ac. winter wheat, crop received heavy hail damage
85.5 ac. summer fallow

Because of a land trade I have no crop information on Section 4 after 1974.

Sincerely yours,

E E. Heinle

E. E. Heinle
Suprv. Croplands

EEH/ja

APPENDIX B.

Productivity data for community types in area E_2.[1]

Community type	Forage Class	Pounds/acre[2]	Standard Error (±)
	Forbs	102	22
212.1	Shrubs	494	243
	Grass	447	70
	Forbs	14	7
212.2	Shrubs	1,255	582
	Grass	811	398
	Forbs	180	84
111.3	Shrubs	332	149
	Grass	815	71
	Forbs	253	130
111.4	Shurbs	492	60
	Grass	849	181
	Forbs	141	56
351	Shrubs	109	57
	Grass	20	16
	Forbs	45	40
211	Shrubs	717	253
	Grass	603	45

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[1] Data from E.C.S., 1974 (3).

APPENDIX D-3

PLANT SPECIES LIST

Compiled by Sindelar and Plantenberg (6)

Plant species occurring in the study area.

List of plant species observed near Colstrip, Mt.

Scientific Name	Common Name
Acer negundo	Box elder
Achillea millefolium	Common yarrow
Agoseris glauca	Pale agoseris
Agropyron albicans	Montana wheatgrass
Agropyron cristatum	Crested wheatgrass
Agropyron dasystachyum	Thickspike wheatgrass
Agropyron elongatum	Tall wheatgrass
Agropyron riparium	Streambank wheatgrass
Agropyron sibericum	Siberian wheatgrass
Agropyron smithii	Western wheatgrass
Agropyron spicatum	Bluebunch wheatgrass
Agropyron trichophorum	Pubescent wheatgrass
Agropyron trachycaulum	Slender wheatgrass
Allium textile	Prairie onion
Allysum alyssoides	Allysum
Amaranthus albus	Pigweed
Amaranthus graecizans	Prostrate pigweed
Amaranthus retroflexus	Redroot pigweed
Ambrosia psilostachya	Western ragweed
Ambrosia trifida	Giant ragweed
Andropogon gerardi	Big bluestem
Andropogon hallii	Sand bluestem
Andropogon scoparius	Little bluestem
Antennaria spp.	Pussytoes
Antennaria microphylla	Littleleaf pussytoes
Antennaria parviflora	Small-leaf pussytoes
Apocynum spp.	Indian hemp
Arabis holboellii	Holboel rockcress
Arenaria hookeri	Hooker sandwort
Argemone intermedia	Intermediate pricklypoppy
Aristida longiseta	Red threeawn
Arnica sororia	Arnica
Artemisia campestris	Common sagewort
Artemisia cana	Silver sagebrush
Artemisia dracunculus	Falsetarragon sagewort
Artemisia frigida	Fringed sagewort
Artemisia ludoviciana	Prairie sagewort
Artemisia tridentata	Big sagebrush
Asclepias spp.	Milkweed
Asclepias pumila	Plains milkweed
Asclepias speciosa	Showy milkweed
Asclepias viridiflora	Green milkweed
Aster spp.	Aster
Aster campestris	Meadow aster
Astragalus spp.	Milkvetch
Astragalus agrestis	Field milkvetch

List of plant species observed near Colstrip, Mt. (cont.)

Scientific Name	Common Name
Astragalus bisulcatus	Twogroove milkvetch
Astragalus cicer	Cicer milkvetch
Astragalus crassicarpus	Groundplum milkvetch
Astragalus geyeri	Geyer milkvetch
Astragalus gilviflorus	Threeleaved milkvetch
Astragalus missouriensis	Missouri milkvetch
Astragalus purshii	Pursh loco
Atriplex spp.	Saltbush
Atriplex canescens	Fourwing saltbush
Atriplex confertifolia	Shadscale saltbush
Atriplex nuttallii	Nuttall saltbush
Atriplex patula	Fathen saltbush
Avena fatua	Wild oat
Avena sativa	Common oat
Besseya spp.	Kittentails
Boletus spp.	(fungi)
Bouteloua curtipendula	Sideoats grama
Bouteloua gracilis	Blue grama
Brassica kaber	Charlock mustard
Bromus spp.	Brome
Bromus arvensis	Field brome
Bromus inermis	Lincoln brome
Bromus japonicus	Japanese brome
Bromus tectorum	Cheatgrass
Buchloe dactyloides	Common buffalograss
Calamagrostis spp.	Reedgrass
Calamagrostis montanensis	Plains reedgrass
Calamovilfa longifolia	Prairie sandreed
Calochortus nuttallii	Sego mariposalily
Camelina microcarpa	Littlepod falseflax
Campanula rotundifolia	Roundleaf harebell
Carex spp.	Sedge
Carex eleocharis	Needleleaf sedge
Carex filifolia	Threadleaf sedge
Carex pennsylvanica	Penn sedge
Castilleja sessiliflora	Downy paintbrush
Centaurea spp.	Centaurea
Cerastium arvense	Field chickweed
Chenopodium spp.	Goosefoot
Chenopodium album	Lambsquarters goosefoot
Chenopodium botrys	Jerusalem oak
Chenopodium leptophyllum	Narrowleaf goosefoot
Chorispora tenella	Blue mustard
Chrysopsis villosa	Hairy goldaster
Chrysothamnus nauseosus	Rubber rabbitbrush
Chrysothamnus viscidiflorus	Green rabbitbrush
Cichorium intybus	Common chicory
Cirsium arvense	Canada thistle

List of plant species observed near Colstrip, Mt. (cont.)

Scientific Name	Common Name
Cirsium undulatum	Wavyleaf thistle
Cirsium vulgare	Bull thistle
Cleome serrulata	Rockymountain beeplant
Collybia spp.	(fungi)
Comandra umbellata	Bastard toadflax
Convolvulus arvensis	Field bindweed
Coryphantha missouriensis	Yellow pincushion cactus
Crepis spp.	Hawksbeard
Cryptantha celosioides	Miners candle
Dactylis glomerata	Orchard grass
Delphinium bicolor	Low larkspur
Descurainia spp.	Tansymustard
Descurainia pinnata	Pinnate tansymustard
Distichlis stricta	Inland saltgrass
Draba reptans	Draba
Echinacea pallida	Purple coneflower
Echinochloa crusgalli	Common barnyardgrass
Eleagnus angustifolia	Russian olive
Elymus canadensis	Canadian wildrye
Elymus cinereus	Basin wildrye
Erigeron spp.	Fleabane
Erigeron divergens	Spreading fleabane
Erigeron pumilis	Low fleabane
Eriogonum spp.	Wildbuckwheat
Eriogonum annuum	Annual eriogonum
Eriogonum pauciflorum	
Erysimum asperum	Plains wallflower
Euphorbia glyptosperma	Ridgeseed spurge
Euphorbia robusta	Robust spurge
Eurotia lanata	Winterfat
Evolvulus nuttallianus	Nuttall evolvulus
Festuca spp.	Fescue
Festuca arundinacea	Tall fescue
Festuca elatior	Meadow fescue
Festuca occidentalis	Western fescue
Festuca octoflora	Sixweeks fescue
Festuca ovina	Hard fescue
Fritillaria atropurpurea	Leopard lily
Fulgensia fulgens	(lichen)
Gaillardia aristata	Common gaillardia
Gaura coccinea	Scarlet gaura
Gaura parvilflora	Smallflower gaura
Geum triflorum	Prairiesmoke
Gilia congesta	Ballhead gilia
Glycyrrhiza lepidota	Wild licorice

List of plant species observed near Colstrip, Mt. (cont.)

Scientific Name	Common Name
Grindelia squarrosa	Curlycup gumweed
Gutierrezia sarothrae	Broom snakeweed
Happlopappus spinulosus	Spiny goldenweed
Helianthus annuus	Common sunflower
Helianthus petiolaris	Prairie sunflower
Hordeum jubatum	Foxtail barley
Hordeum vulgare	Sixrow barley
Hymenopappus filifolius	Fineleaf hymenopappus
Iva axillaris	Poverty weed
Iva xanthifolia	Marshelder
Juniperus horizontalis	Creeping juniper
Juniperus scopulorum	Rockymountain juniper
Kochia scoparia	Summer cypress
Koeleria cristata	Prairie junegrass
Lactuca pulchella	Blue lettuce
Lactuca serriola	Prickly lettuce
Lathyrus bijugatus	Drybard peavine
Lepidium spp.	Pepperweed
Lepidium densiflorum	Prairie pepperweed
Lesquerella alpina	Alpine bladderpod
Leucocrinum montanum	Common starlily
Liatris punctata	Dotted gayfeather
Linum campanulatum	Harebell flax
Linum perenne	Perennial flax
Linum rigidum	Stiffstem flax
Lithospermum incisum	Narrowleaf gromwell
Lomatium spp.	Biscuitroot
Lupinus spp.	Lupine
Lygodesmia juncea	Rush skeletonplant
Medicago sativa	Alfalfa
Melilotus alba	White sweetclover
Melilotus officinalis	Yellow sweetclover
Mentzelia decapetala	Tenpetal blazingstar
Microseris cuspidata	Toothed microseris
Muhlenbergia cuspidata	Plains muhly
Musineon divaricatum	Wild parsely
Noctac spp.	(algae)
Oenothera spp.	Eveningprimrose
Oenothera albicaulis	Prairie eveningprimrose
Oenothera nuttallii	Nuttall eveningprimrose
Oenothera serrulata	Shubby eveningprimrose
Onobrychis viciaefolia	Sainfoin
Opuntia fragilis	Brittle pricklypear
Opuntia polyacantha	Plains pricklypear

List of plant species observed near Colstrip, Mt. (cont.)

Scientific Name	Common Name
Orthocarpus luteus	Yellow owlclover
Oryzopsis hymenoides	Indian ricegrass
Oxytropis spp.	Loco
Oxytropis besseyi	Bessey loco
Oxytropis sericea	Whitepoint loco
Panicum virgatum	Switchgrass
Parmelia chlorochroa	(lichen)
Penstemon spp.	Penstemon
Penstemon albidus	White penstemon
Petalostemon candidum	White prairieclover
Petalostemon oligophyllum	Slender white prairieclover
Petalostemon purpureum	Purple prairieclover
Phacelia linearis	Threadleaf phacelia
Phleum pratense	Common timothy
Phlox spp.	Phlox
Phlox alyssifolia	Allysum-leaved phlox
Phlox hoodii	Hoods phlox
Physalis longifolia	Longleaf groundcherry
Pinus ponderosa	Ponderosa pine
Plantago patagonica	Woolly plantain
Poa spp.	Bluegrass
Poa juncifolia	Alkali bluegrass
Poa pratensis	Kentucky bluegrass
Poa sandbergii	Sandberg bluegrass
Polemonium spp.	Polemonium
Pollybastia obsoleta	(lichen)
Polygala alba	White polygala
Polygonum spp.	Knotweed
Polygonum douglasii	Douglas knotweed
Populus spp.	Cottonwood
Populus angustifolia	Narrowleaf cottonwood
Populus deltoides	Eastern cottonwood
Potentilla spp.	Cinquefoil
Potentilla glandulosa	Gland cinquefoil
Prunus americana	American plum
Prunus virginiana	Chokecherry
Psoralea argophylla	Silverleaf scurfpea
Psoralea esculenta	Common breadroot scurfpea
Psoralea tenuifolia	Slimflower scurfpea
Puccinellia airoides	Nuttall alkaligrass
Purshia tridentata	Bitterbrush
Ratibida columnifera	Prairie coneflower
Rhus radicans	Poison ivy
Rhus trilobata	Skunkbrush sumac

List of plant species observed near Colstrip, Mt. (cont.)

Scientific Name	Common Name
Ribes aureum	Golden currant
Ribes cereum	Squaw currant
Ribes setosum	Redshoot gooseberry
Rosa arkansana	Prairie rose
Rosa woodsii	Woods rose
Rumex crispus	Curly dock
Salsola kali	Russian thistle
Sarcobatus vermiculatus	Greasewood
Schedonnardus paniculatus	Tumblegrass
Secale cereale	Common rye
Senecio spp.	Groundsel
Senecio canus	Woolly groundsel
Senecio plattensis	Prairie groundsel
Seteria spp.	Bristlegrass
Shepherdia argentea	Buffaloberry
Silene cserei	Smooth catchfly
Sisymbrium altissimum	Tumbling mustard
Sisymbrium loeselii	Tall hedgemustard
Sisyrinchium spp.	Blueeyedgrass
Sitanion hystrix	Bottlebrush squirreltail
Solanum triflorum	Cutleaf nightshade
Solidago spp.	Goldenrod
Solidago canadensis	Canada goldenrod
Solidago missouriensis	Missouri goldenrod
Solidago mollis	Velvety goldenrod
Solidago rigida	Stiff goldenrod
Sorghum sudanense	Sudangrass sorgho
Sphaeralcea coccinea	Scarlet globemallow
Sporobolus airoides	Alkali dropseed
Sporpbolus cryptandrus	Sand dropseed
Stelleria media	Chickweed
Stephanomeria runcinata	Desert wirelettuce
Stipa comata	Needle and thread grass
Stipa viridula	Green needlegrass
Symphoricarpos albus	Common snowberry
Symphoricarpos occidentalis	Western snowberry
Taraxacum officinale	Common dandelion
Tetradymia canescens	Gray horsebrush
Thelasperma marginatum	Greenthread
Thermopsis rhombifolia	Goldenpea
Thlaspi arvense	Field pennycress
Tortula spp.	(moss)
Townsendia exscapa	Stemless townsendia
Tradescantia bracteata	Bracted spiderwort
Tragopogon dubius	Yellow salsify

List of plant species observed near Colstrip, Mt. (cont.)

Scientific Name	Common Name
Tribulus terrestris	Puncturevine feverplant
Trifolium spp.	Clover
Triticum aestivum	Bread wheat
Tulostoma spp.	(fungi)
Typha latifolia	Common cattail
Vaccaria segetalis	Cowcockle
Verbascum thapsus	Flannel mullein
Vicia spp.	Vetch
Vicia americana	American vetch
Viola nuttallii	Nuttall violet
Xanthium spp.	Cocklebur
Yucca glauca	Small soapweed
Zygadenus venenosus	Meadow deathcamus

APPENDIX D-4

SPECIES OF WILDLIFE IN THE REGION

APPENDIX E.

Species of wildlife in the region. [1]

	Scientific Name	Common Name
MAMMALS:	Antilocapra americana	Pronghorn antelope
	Canis latrans	Coyote
	Cynomys ludovicianus	Black-tailed prairie dog
	Erethizon dorsatum	Porcupine
	Eutamias minimus	Least chipmunk
	Lepus townsendii	White-tailed jackrabbit
	Lynx rufus	Bobcat
	Marmota flaviventris	Yellow-bellied marmot
	Mephitis mephitis	Striped skunk
	Microtus ochrogaster	Prairie vole
	Mus musculus	House mouse
	Mustela frenata	Longtail weasel
	Myotis lucifugus	Little brown bat
	Odocoileus hemionus	Mule deer
	Odocoileus virginianus	White-tailed deer
	Ondatra zibethicus	Muskrat
	Onychomys leucogaster	Grasshopper mouse
	Perognathus fasciatus	Olive-backed pocket mouse
	Peromyscus maniculatus	Western deer mouse
	Procyon lotor	Racoon
	Reithrodontomys megalotis	Harvest mouse
	Sorex cinereus	Masked shrew
	Spermophilus tridecemlineatus	Thirteen-lined ground squirrel
	Sylvilagus audubonnii	Desert cottontail
	Taxidea taxus	Badger
	Thomomys talpoides	Northern pocket gopher
	Vulpes vulpes	Red fox
BIRDS:	Actitis macularia	Spotted sandpiper
	Aeronautes saxatalis	White-throated swift
	Agelaius phoeniceus	Red-winged blackbird
	Ammodramus savannarum	Grasshopper sparrow
	Anas acuta	Pintail
	Anas cyanoptera	Cinnamon teal
	Anas discors	Blue-winged teal
	Anas platyrhynchos	Mallard
	Anas strepera	Gadwall
	Aquila chrysaetos	Golden eagle
	Ardea herodias	Great blue heron
	Asio flammeus	Short-eared owl
	Bartramia longicauda	Upland plover
	Branta cananadensis	Canada goose
	Bubo virginianus	Great horned owl
	Buteo jamaicensis	Red-tailed hawk

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[1] Data from Ecological Consulting Service (10) and Lewis, Morton and Jones (13).

Species of wildlife in the region. (continued)

	Scientific Name	Common Name
BIRDS:	Calamospiza melanocorys	Lark bunting
	Capella gallinago	Common snipe
	Centrocercus urophasianus	Sage grouse
	Charadrius vociferus	Killdeer
	Chondestes grammacus	Lark sparrow
	Chordeiles minor	Common night hawk
	Circus cyaneus	Marsh hawk
	Coccyzus americanus	Yellow-billed cuckoo
	Colaptes cafer	Red-shafted flicker
	Contopus sordidulus	Western wood pewee
	Corvus brachyrhynchos	Common crow
	Dendroica auduboni	Audubon warbler
	Dendroica petechia	Yellow warbler
	Dumetella carolinensis	Catbird
	Empidonax oberholseri	Dusky flycatcher
	Eremophila alpestris	Horned lark
	Euphagus carolinus	Rusty blackbird
	Euphagus cyanocephalus	Brewer's blackbird
	Falco sparverius	Sparrow hawk
	Falco mexicanus	Prairie falcon
	Fulica americana	American coot
	Geothlypis trichas	Yellowthroat
	Gymnorhinus cyanocephala	Pinyon jay
	Haliaeetus leucocephalus	Bald eagle
	Hirundo rustica	Barn swallow
	Icteria virens	Yellow-breasted chat
	Icterus bullockii	Bullock's oriole
	Lanius ludovicianus	Loggerhead shrike
	Loxia curvirostra	Red crossbill
	Mareca americana	American widgeon
	Melanerpes erythrocephalus	Red-headed woodpecker
	Melospiza melodia	Song sparrow
	Molothrus ater	Brown-headed cowbird
	Parus atricapillus	Black-capped chickadee
	Passer domesticus	House sparrow
	Pedioecetes phasianellus	Sharp-tailed grouse
	Perdix perdix	Hungarian partridge
	Petrochelidon pyrrhonota	Cliff swallow
	Phasianus colchicus	Ring-necked pheasant
	Pheucticus melanocephalus	Blackheaded grossbeak
	Pica pica	Magpie
	Pipilo erythrophthalmus	Rufous-sided towhee
	Pooecetes gramineus	Vesper sparrow
	Quiscalus quiscula	Common grackle
	Rhynchophanes mccownii	McCown's longspur
	Riparia riparia	Bank swallow

Species of wildlife in the region. (continued)

	Scientific Name	Common Name
BIRDS:	Salpinctes obsoletus	Rock wren
	Syarnis saya	Say's phoebe
	Setophaga ruticilla	American redstart
	Sialia currucoides	Mountain bluebird
	Sitta carolinensis	White-breasted nuthatch
	Spatula clypeata	Shoveller
	Spinus tristis	American goldfinch
	Spizella breweri	Brewer's sparrow
	Spizella pallida	Clay-colored sparrow
	Steganopus tricolor	Wilson's phalarope
	Stelgidopteryx ruficollis	Rough-winged swallow
	Sturnella neglecta	Western meadowlark
	Sturnus vulgaris	Starling
	Tachycineta thalassina	Violet-green swallow
	Toxostoma rufum	Brown thrasher
	Troglodytes aedon	House wren
	Turdus migratorius	Robin
	Tyrannus tyrannus	Eastern kingbird
	Tyrannus verticalis	Western kingbird
	Vireo olivaceus	Red-eyed vireo
	Zenaidura macroura	Mourning dove
	Zonotrichia leucophrys	White-crowned sparrow
REPTILES:	Chelyara serpentina	Common snapping turtle
	Chrysemys picta	Western painted turtle
	Coluber constrictor	Racer
	Crotalus viridis	Prairie rattlesnake
	Heterodon nasicus	Hognose snake
	Pituophis catenifer	Bull snake
	Scelopamus graciosus	Sagebrush lizard
AMPHIBIANS:	Rana pipiens	Leopard frog

APPENDIX D-5

DESCRIPTION OF AREA E GRADED SPOILS RESEARCH AREA

BY DR. BRIAN SINDELAR, M.S.U.

Montana State University

College of Agriculture

Agricultural Experiment Station
Bozeman, Montana 59715 Tel. 406-994-3721

Animal and Range Sciences Department

March 11, 1977

Dr. Dana Schmidt
Olson-Elliott & Associates
P. O. Box 1209
Helena, MT 59601

Dear Dr. Schmidt:

In response to your recent inquiry concerning my ERDA-sponsored research in Area E near Colstrip, I am providing you with more detailed information. You should soon receive a copy of the annual progress report which explains the study in depth.

Five of our 13 study sites consist of overburden material placed on rangeland in flattened mounds in 1924. To my knowledge these sites represent the oldest leveled mine spoils in southeastern Montana. I specificially mention "leveled" in that unleveled spoils are characteristically unstable and are normally incapable of sustaining typical continuous vegetational progression. This is due to their steepness and consequent precipitation runoff, surface erosion, and their slope orientation. Leveled spoils more accurately reflect the kind and rate of plant succession that might be expected on mined lands undergoing reclamation. I am not aware of any other leveled coal spoils of this age in Montana. This is one of the most important values of the "1924" sites.

Another major value of the 1924 sites is that, although over 50 years old, several of the sites remain in low seral stages. They are still dominated by cheatgrass and false-tarragon sagewort, both considered undesirable range weeds. This is in sharp contrast to younger (1932) leveled spoils that have progressed to relatively high seral stages. It is of considerable importance to determine the bases for the very slow rate of succession on the 1924 sites in order to assure that similar conditions are not recreated by current mining practices. There is a unique opportunity to discover the reason(s) for this phenomenon through detailed study of the five 1924 sites. Some of the five sites are more advanced successionally than the others. In fact the five sites, which are located along a mile-long north-south axis, appear to represent a series of successional stages. Each site, beginning with the southernmost (1924-1), is somewhat more successionally advanced. The northernmost site (1924-6) has perennial grasses and forbs and is similar to poor condition native rangeland. The five 1924 sites are on similar overburden materials with no apparent chemical or physical differences.

Because of the unique and important ecological nature of the 1924 sites, ERDA has funded two graduate research studies which deal specifically with them. These studies are in addition to the overall research effort I'm conducting on mined land plant succession. Each graduate student began studies on the sites in April 1976, and collected basic data through the 1976 growing season. To fully implement their individual research plans they must collect additional data of a different nature through the 1977 growing season. With these data, mysteries of the 1924 sites should be revealed. This would surely provide a better understanding of successional changes presently occurring on recently mined and revegetated lands in eastern Montana.

Other scientists have recognized the value of the 1924 sites and initiated studies on them in spring 1976. The Cooperative States Research Service funded a Montana Agricultural Experiment Station study, "The Effect of Time on Root Characteristics, Soil Genesis, and Hydrologic Properties of Strip Mine Spoils," which utilizes three of the 1924 spoil mounds. Dr. Nielsen, Dr. Dollhopf, and Mr. Schafer of MSU are conducting the study. In addition, a graduate thesis project is associated with the study. This research is scheduled to continue into the 1977 growing season.

After reporting the ERDA research at Argonne National Laboratory's Land Reclamation Program in Chicago recently, several reclamation researchers indicated plans to visit the sites. These scientists include: Dr. James Carel, University of Missouri; Dr. Becky Green, Argonne National Lab; and Dr. Mike Miller, Argonne National Lab. Dr. Ralph Carter, Director of the Land Reclamation Program also expressed his interest in the project.

Considerable expense and effort has been invested in the 1924 sites to date. ERDA funding through this year will total $125,000. Without the detailed work planned for the 1977 growing season, much of the value of the 1924 sites would be lost.

I should add that only two years of data collection were anticipated on the 1924 sites because Western Energy Company indicated its plans to mine the area. At the time we initiated the research I understood that two growing seasons would be available for study. I was distressed to hear that the sites may be destroyed this spring. Such an occurrence would certainly reduce the value of work conducted on the sites to date, and would essentially prevent determination of the reason why these sites remain in lower stages of successional development.

It is my opinion that the 1924 sites should not be mined or disturbed in any way prior to collection of critical vegetational data in the 1977 growing season. While every effort can and will be made to retrieve all data from the sites as soon as physically possible, certain sampling dates are determined by nature itself. Peak vegetational biomass in the Colstrip area normally occurs at about the end of July or beginning of August. This is one of the most critical measures and along with plant cover is a basis for our successional analyses. And should this be a year of drought, these data become even more critical.

I also believe that two complete years of detailed documentation such as indicated in our annual report will provide an acceptable preservation of the 1924 sites following their destruction by mining. A single year will not. Obviously, additional studies on the 1924 sites could be continued for years if it was not necessary to mine them. However, academic value beyond that provided by the current two-year study can be satisfied to a great extent by our 1932 site (Cape Oliver).

I hope that this discussion will be of value to you in your work. Please contact me if I can be of further service.

Sincerely,

Brian Sindelar

Brian W. Sindelar
Research Associate

BWS/mfs

APPENDIX E-1

YELLOWSTONE RIVER SUBBASIN USE

APPENDIX E-1

Current land use in Rosebud County is shown in Table 30; similar use categories for the Northern Cheyenne Reservation are shown in Table 31. Land use makeup for the Yellowstone River subbasin as of 1972 on a percentage breakdown. Because of the various sources and differing categories used by the compilers of this data, no attempt will be made here to correlate the findings of each table in a uniform manner.

YELLOWSTONE RIVER SUBBASIN LAND USE, 1972

USE	Breakdown 1,000 Acres	%
Pasture and Range	33,628	74
Forest and Woodland	6,100	14
Cropland	3,400	8
Recreation	1,400	3
Urban and Transportation	200	-
Fish and Wildlife	50	-
Mineral Industry	10	-
Military	10	-
Other Agriculture	100	-
Water	300	-
TOTAL	45,198	

Source: Proposed Federal Coal Leasing Program, Draft Environmental Impact Statement, Volume 1, U.S. Department of the Interior, Bureau of Land Management, 1974; p. 11-174.

APPENDIX E-2

SECTOR EMPLOYMENT AND SECTOR INCOME PER EMPLOYEE

APPENDIX E-2

A picture of the structure of the Rosebud County economy can be obtained by looking at the distrubution of employment between sectors shown in table 1. The agricultural sector's share of the total fell from 27 percent to 20 percent as its employment remained relatively constant and the rest of the sectors added workers. Mining and construction now account for 13 percent, while trade and services have almost 20 percent of the total. This compares to corresponding percentages of 3 and 24, respectively, in 1974.

Average annual income per employee was calculated by dividing each sector's income by its employment and the results are listed in table 2. This gives some notion of the wide invome variations among sectors and how these have changed since 1970. The highest paid sector and the one with the greatest change is the construction sector with income of $15,905 per employee per year, no doubt as a result of the power plant construction at Colstrip. Despite the high wages in this sector, the average nonagricultural income in Rosebud County remains below the state average. The fact that including agricultural income increases the county average, except in 1974, emphasizes the continued importance of this sector to the Rosebud economy.

Reconciliation of the census and the BEA income series is more difficult than for employment. Total income from the census was $13,928,000 for 1969, and the 1969 total personal income figure from BEA was $17,772,000. Once again, the discrepancy is due to definitional differences between the two series. The BEA income series includes such income as "in kind", income of non-profit organizations, the value of services of banks and other financial firms rendered to persons without charge, and Medicare payments. These items are not included by the census. Moreover, the census data are obtained directly from households, while the BEA series is estimated largely on the basis of data from the administration records of business and governmental sources. Since reconciliation is not critical for the impact assessment process, no adjustments were attempted.

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1. Although there are sources of potential error in the estimation method it is the best, consistent method available.

2. This is generally referred to as hidden unemployment.

3. Welfare, religious, and nonprofit organizations includes such things as the St. Labre School, tribal employment, churches and various social service groups.

4. Median family income is that income level for which there is an equal number of families above and below.

TABLE 1

DISTRIBUTION OF EMPLOYMENT IN ROSEBUD COUNTY, 1970-1974 (GIVEN AS PERCENTAGE OF TOTAL EMPLOYMENT)

Sector	1970	1971	1972	1973	1974
Agriculture[a]	27.4	25.6	23.8	21.5	20.3
Mining	1.6	2.8	3.5	8.1	8.1
Construction	1.1	.9	1.3	2.3	5.1
Manufacturing	8.4	8.2	8.9	5.8	5.1
Transportation, Communication, Public Utilities	7.2	6.5	6.3	5.8	5.8
Trade	8.5	8.7	9.0	10.1	9.8
Finance, Insurance, Real Estate	.7	.9	1.2	1.3	1.5
Services	15.5	18.4	18.9	19.7	19.1
Government	18.4	16.5	15.9	15.0	15.5
Other[a]	12.1	11.5	11.2	10.2	9.5
TOTAL	100.0	100.0	100.0	100.0	100.0

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[a] Includes self-employed proprietors.

Source: Derived.

TABLE 2

INCOME PER EMPLOYEE, ROSEBUD COUNTY, 1970-1974
(CURRENT DOLLARS)

Sector	1970	1971	1972	1973	1974
Agriculture	8272	8454	11244	17097	5182
Mining	13214	10215	10718	13609	13738
Construction	8000	5160	7743	10394	15738
Manufacturing	4389	4812	4265	4801	5605
Transportation, Communication, Public Utilities	8554	9110	9770	10931	10961
Trade	3310	3409	3476	3590	4951
Finance, Insurance, Real Estate	4631	5077	5216	5595	7038
Services	3896	3728	4176	4094	4923
Government	5613	6136	6525	7083	7511
Other	4042	3428	3581	3766	4214
Rosebud Total	5944	5954	6750	8630	7007
Rosebud Non-Ag Total	5066	5095	5344	6316	7473
Montana Total	6378	6432	7359	8325	NA
Montana Non-Ag Total	6093	7617	6743	7124	NA
Rosebud/Montana					
Total	.93	.92	.92	1.04	NA
Non-Agriculture	.83	.76	.79	.89	NA

Source: Derived.

APPENDIX E-3

DETAILED DESCRIPTIONS OF ROSEBUD COUNTY'S SCHOOL DISTRICTS

APPENDIX E-3

Nine school districts are located within Rosebud County. Enrollment varies from 12 to 685 and those districts most impacted by the growth of Colstrip are undergoing construction, and/or other improvements. A brief description of each follows:

District #2

District #2 in Angela includes Grades 1 through 6 and has a student enrollment of six with one teacher. The condition of the school building is good, and has a capacity of 12 to 15 students. Busing mileage within the district is 16 miles.

District #33

The Ingamar District #33, has a 1976-1977 student enrollment of 25 in grades 1 through 8 and employes four teachers and staff. Speech therapy and special education are available. The building is considered adequate with a capacity of 32 students.

District #3

District #3 in Birney has a student enrollment of 12 in grades 1 through 12, and two teachers, however, next year there will be only one. The school building is in good condition and has a capacity of 26.

District #6

Lame Deer, District #6, offers a K-8 grade curriculum with an enrollment of 415 students. The teachers and other staff number 24. The school is considered in good condition.

District #32J

Enrollment for the 1976-1977 school term was 92 students, with ten teachers and staff. The building program by the Ashland district will double the present facility, adding approximately 20,000 square feet and

and a gym with a seating capacity of 300. The entire project is expected to take 8 to 12 months to complete once construction is begun this summer. The new facility will also be available for various community activities.

District #12

District #12, in Rosebud, includes grades K-12, with a present student population of 168. The school is housed in one building with the elementary school wing (gr. 1-6) and the high school wing (gr. 7-12) separated by the lunchroom. The school is in excellent condition; the elementary school is at capacity, and the high school could absorb approximately 15 more students. There are 15 teachers and other staff in the district. Construction was begun in December, 1976, to add elementary rooms and a music room. Completion will be in September, 1977.

District #4

Forsyth, at present, is the largest district in Rosebud County with total enrollment of 685 students; the elementary school has 349 students, the middle school, 105 students, and the high school, 231 students. There are 47 teachers, 4 administrators, and 22 non-certified staff within the district. Construction of two new buildings is expected to commence this summer with completion within 12 to 16 months. One building will accommodate grades K-5 and the other will house grades 6-8. Together these will double the capacity of the elementary school.

District #19

School District #19 in Colstrip is also in the midst of a building program. A bond issue for $2,893,730 has been passed for the construction of an elementary school, the remodeling of the high school, with addition for a shop, girl's locker room, weight and wrestling room, and food service receiving and storage. Construction is expected to begin in the early summer of 1977, with a completion date of January, 1978. The building program will give the district an elementary school capacity of 400 and high school capacity of 300. Future growth for the district has been provided for in the event Colstrip Units 3 and 4 are constructed.

At present the district is housed in two building with 310 elementary students and 387 junior and senior high students, and 43 teachers and staff.

APPENDIX E-4

Table 1	Highway Status - Rosebud County
Table 2	Average Daily Traffic Counts

TABLE 1

HIGHWAY STATUS: ROSEBUD COUNTY

Route Designation	Surface Type[1]	1975 Average Daily Traffic (ADT)[2]	Planned Improvements and/or Changes[3]	1990 Functional Classification[4]
INTERSTATE HIGHWAYS				
I-94 (US10, 312)	2,4 Lane Paved	3340[5]--entering from west 3160[5]--entering from east	Widen to 4-Lane: Forsyth area 10 miles, anticipated completion, 1980; Hysham area 21.6 miles, anticipated completion July, 1977; Hathaway area 5.6 miles, anticipated completion 1979; funds through Interstate Programs	Interstate system
PRIMARY HIGHWAYS				
US 12 (FAP 14)	2 - lane Paved	243 Mussellshell & Rosebud Co. lines 245 Sumatra 223 Ingomar 253 Vananda 759[6] entering Forsyth		Minor arterial
FAP 2	2 - lane Paved	109 M.P. 551 562 M.P. 560 132 M.P. 571 283 M.P. 577 241 M.P. 578 128 M.P. 580		Major collector

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1. General Highway Maps, Rosebud County, Montana prepared by Montana State Highway Commission, Planning Survey section, December, 1961, revised December 31, 1973.
2. Average Daily Traffic Counts, Department of Highways, State of Montana.
3. Les Harris, Planning and Research Bureau, Montana State Highway Commission, Helena, Montana: Communication March 17, 1977.
4. State of Montana 1990 Highway Functional Classification, January, 1971, revised June 1, 1974.
5. 1976 survey
6. 1974 survey

TABLE 1 (continued)

Route Designation	Surface Type	1975 Average Daily Traffic (ADT)	Planned Improvements and/or Changes	1990 Functional Classification
OTHER HIGHWAYS				
SECONDARY HIGHWAYS				
FAS 315	2 - lane Paved	1243[5]--I-94 to 315 (1975 data) 1055[5]--12 miles south of I-94 964[5]--7 miles north of Colstrip 1779[5]--Just north of Colstrip 1133[5]--Just south of Colstrip junction 328[5]--13 miles north of Lame Deer 807[5]--Just north of Lame Deer	Upgrade road to meet secondary road standards--from I-94 south to Lame Deer, total of 52 miles. Proposed first priority for coal impact funds--work to be done by 1980.	Minor arterial to south of 212 where it becomes a minor collector
FAS 447	2 - lane Paved from I-94 south for 8 miles then gravel graded and drained	248 M.P. 0.0 (Junct. FAP 2) 176 M.P. .079 5 M.P. 3 81 M.P. 32 220 M.P. 53	Upgrade road to secondary road standards from I-94 south to Ashland, a total of approximately 55 miles. Proposed for improvement with coal impact funds, work to be done by 1980. Also scheduled for improvements with economic growth funds for 80 miles of grading and graveling in 1978--improvements proposed under coal impact plans will probably take precedence.	Major collector
FAS 446	2 - lane Paved from Rosebud for 10 miles east	249 Junct. FAP 2 at Rosebud 131 Cartersville		Minor collector

TABLE 1 (continued)

Route Designation	Surface Type	1975 Average Daily Traffic (ADT)	Planned Improvements and/or Changes	1990 Functional Classification
UNDESIGNATED MAJOR ROADS				
Road north of Yellowstone River from Forsyth to Rosebud	2 - lane Gravel graded and drained			Major collector
Road from FA311 at Alkalai Creek to Sumatra	2 - lane Gravel graded and drained for 3 miles north then dirt graded and drained to county line then gravel to Sumatra		County has made request for systems funding for 19 miles of graveling	Minor collector

TABLE 1 (continued)

Route Designation	Surface Type	1975 Average Daily Traffic (ADT)	Planned Improvements and/or Changes	1990 Functional Classification
East-west road from Sarpy Creek Road to Colstrip intersecting Sarpy Creek Road near Horse Creek	2 - lane Gravel graded and drained	278[6]--1 mile west of Colstrip		Minor collector
Road along Great Porcupine Creek north of FAP 14	2 - lane Gravel graded and drained			Minor collector
Road north of Forsyth crossing Little Porcupine Creek	2 - lane Gravel graded and drained for 11 miles north then dirt graded drained			Minor collector

TABLE 1 (continued)

Route Designation	Surface Type	1975 Average Daily Traffic (ADT)	Planned Improvements and/or Changes	1990 Functional Classification
Road along Rosebud Creek between FAS 447 and FAS 315	2 - lane Gravel graded and drained			Minor collector
Road from 314 north of Decker to Birney	2 - lane Gravel graded and drained		Upgraded to secondary road standards from 314 to Birney approximately 25 miles; Proposed for coal impact funds, unscheduled date.	Major collector
Road from Decker northeast towards Otter	2 - lane Gravel graded and drained			Minor collector

TABLE 2

AVERAGE DAILY TRAFFIC COUNTS (ADT's)

		ADT's										
YEAR		1963	1965	1967	1969	1970	1971	1972	1973	1974	1975	1976
Sheet 5*	Sta 16**	1150	1253	1308	193	157	145		780	145	160	158
	Sta 20	1219	1276	1360	294	189	180	163	232	255	260	185
	Sta 21	1322	1470	1479	268	346	300	277	362	400	393	468
	Sta 26	1564	1543	1589	1859	2289	2371	2548	3086	3095	3400	3343
	Sta 27	1622	1778	1812	2319	2517	2605	2630	2993	2917	3221	3159
	Sta 34									985	731	
Sheet 6	Sta 10	1289	1350	1454	1904	2019	54	81	42	91	130	167
	Sta 14	83	68	70	90	110	100	102	115	95	92	86
	Sta 15	1241	1300	1458	1763	2148	170	280	428	313	380	316
	Sta 30						33	46	77	75	128	
Sheet 7	Sta 2	106	104	109	191	289	242	385	994	810	940	1050
	Sta 12	51	47	36	38	34	33	29	40	30	40	37
	Sta 19	135	119	120	199	230	327	610	1357	1282	1759	1507
	Sta 21	96	121	130	169	150	140	367	682	544	573	752
	Sta 30	30	37	31	54	50	39	25	26	29	40	48
Sheet 8	Sta 3	104	119	118	140	181	109	215	332	328	340	378
	Sta 7	64	65	52	85	80	79	61	54	60	90	82
	Sta 11	242	240	271	349	431	508	553	726	717	1080	807
	Sta 12	624	668	762	950	904	942	1067	1094	927	1232	1134
	Sta 13	607	654	797	850	896	830	974	998	1058	1338	1263
	Sta 14					253	306	283	277	423	356	431
	Sta 19	596	551	604	720	692	688	690	707	789	890	758
	Sta 21					174	165	210	199	220	220	375
	Sta 26	56	72	50	72	60	73	96	121	99	60	175
	Sta 39	565	554	599	736	734	759	754	773	850	950	1107
Sheet 9	Sta 11									87	107	
	Sta 18									60	33	
	Sta 24									66	58	

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* Refers to portion of Montana Highway Department Map of Rosebud County
** Stations are identified as follows:

Sheet 5
16 - 4 miles east from Treasure/Rosebud County line on Highway 312/10
20 - ½ mile west of Highway 312 and 315 Junction
21 - 1 mile east of Highway 312 and 315 Junction
34 - 4 miles east of Highway 315 on Highway 312/10
26 - ½ miles west of Forsyth on Highway 312/10
27 - ½ mile east of Forsyth on Highway 312/10

Sheet 6
10 - 6 miles east of Forsyth on Highway 312/10
14 - 4 miles south on FAS 447
15 - ¼ mile west of Rosebud on Highway 312/10
30 - 1½ miles east of Rosebud on Highway 312/10

Sheet 7
2 - 15 miles north of Colstrip on FAS 315
12 - 18 miles north of Junction 315 on FAS 447
19 - 1 mile north of Colstrip on FAS 315
30 - ½ mile south of Junction FAS 447 and Rosebud Creek Road
21 - 1 mile south of Colstrip on FAS 315

Sheet 8
3 - 11 miles north of Lame Deer on FAS 315
7 - 8 miles north of Ashland on gravel road
11 - ½ mile north of Lame Deer on FAS 315
12 - ½ mile east of Lame Deer on 212
13 - ½ mile west of Lame Deer on 212
14 - ½ mile south of Lame Deer on FAS 315
19 - 8 miles east of Lame Deer on 212
21 - 1 mile north of Ashland on gravel road
26 - ½ mile south of Highway 212 on road to Birney
39 - 1 mile west of AShland on Highway 212

Sheet 9
11 - 1 mile north of Birney on gravel road
18 - 7 miles southwest of Birney on gravel road
24 - 1 mile southwest of Birney on gravel road

APPENDIX E-5

CORRESPONDENCE CONCERNING THE SURGE POND RECREATION AREA

STATE OF MONTANA

DEPARTMENT OF
FISH AND GAME

P.O. Box 430
Miles City, MT. 59301
August 5, 1976

Martin White
Western Energy Co.
Colstrip, MT. 59323

Dear Martin:

We sampled the fish population in the Surge Pond with a 50-foot bag seine on August 3 and were pleased with what we found.

Our efforts were concentrated along the southeast shore-line in 2-4 foot deep water. Bottom materials ranged from gravel and sand to mud. In nine seine hauls, we took a total of 23 small fish. The northern pike have shown tremendous growth since they were stocked in June. The nine northerns we took averaged 220 mm (8.7 inches) in length. A catch rate of 1 northern per net haul is a good indication of a fairly high survival rate for these fish. The crappie were successful in getting off a spawn because we did pick up some young-of-the-year (both black and white crappie). These too showed good growth averaging about 70 mm (2.8 inches) in length. Young crappie from the Tongue River Reservoir are only about 40 mm (1.6 inches) in length right now. I'm sure the northerns were able to utilize the small crappie as a food base. However, the crappie have now reached a size which will be difficult for the northerns to utilize. Therefore, I'm going to try to obtain some fathead minnows to transplant into the pond. They will serve as food for northerns, bass and crappie. The bass did survive the plant and are still pretty small. The northerns are probably taking their share of them too.

Aquatic vegetation has got a good start and should provide some excellent habitat for small fish and invertebrates. We were surprised to not find any river-type fish. If anything is coming through the pump, they are being chewed up. This will help to maintain a pure population. We did come up with an immature tiger salamander, however.

Since the northerns appear to have survived the plant and will probably become well established in the reservoir, I'd like to suggest some possible water management alternatives to enhance northern pike production Northerns spawn in the spring, soon after the ice goes off. They move into shallow water and lay their eggs on flooded vegetation. Incubation takes about 10-15 days and the fry remain attached to the vegetation for several days after hatching. The vegetation remains important as escape cover until mid-summer when the northerns begin foraging on other fish and move into deeper water.

Ideally then, water levels should be high enough in the spring to cover the vegetation and remain somewhat stable, at least during the incubation period. As the young fish move into deeper water (mid-June) water levels could be dropped a foot or two which then allows revegetation in the shallow spawning areas. Thus the critical water level period for the northerns is April-June. The Department understands the need-use concept involved with the surge pond water, but recommends that unnecessary use of this water during this period be minimized. I think by planning maintenance around this period we should be able to produce some pretty fantastic northern pike fishing in this lake.

Thanks for the opportunity to sample the pond and for allowing us to suggest possible water level management schemes. If you have any questions please call.

Best regards,

Al

Allen A. Elser
Regional Fisheries Manager

AAE:fr

cc: Carl Anderson
Art Whitney
Jim Posewitz

APPENDIX E-6

EVALUATION OF LANDSCAPES WITHIN A ONE-DAY TRAVELING DISTANCE

APPENDIX E-6

Evaluation of Landscapes Within a One-Day Traveling Distance:

The objective of this discussion is to provide a perspective on the scenic quality and value of Areas A and E as they relate to other major types of landscapes within a one-day traveling zone from the study site. A one-day travel zone extends as far west as the Beartooth Mountains, northwest to the Lake Mason National Wildlife Refuge, northeast to Miles City, and south to the Bighorn Mountains. Within this radius there is a wide variety of scenery ranging from flat, open agricultural fields, eroded badlands, dissected plateaus, to dramatic alpine mountains and streams.

A vast band of deeply dissected plateaus and valleys created by numerous drainages and creeks extends in a northwest to southeast direction from the Bull Mountains to Wyoming except for a relatively narrow area of flatter terrain between the Bull Mountains and the Yellowstone River.

Although a similar physiographic character persists thorughout this expansive area, scenically there are notable variations due primarily to elevation and vegetation differences. Areas of greater elevation range generally have more abrupt and better defined physiographic features than are found in the Colstrip area. The most visible evidence of these areas are the Bull Mountains (elevations range 3,100 to 4,700 feet), the Rosebud Mountains (3,700 to 5,200 feet), the Wolf Mountains (3,300 to 4,700 feet), the Little Wolf Mountains (3,400 to 4,800 feet) and the Spray Mountains (3,300 to 4,500 feet). These landforms are characterized by steep terrain, exposed rock areas and well defined canyons and valleys. Locationally, all of these landforms are east and southeast of the Colstrip area, except for the Bull Mountains which are to the northwest.

In general, water features are scarce within this portion of the region, although water has had a significant influence on landforms and the distribution of vegetation.

A second major landscape type within a one-day travel zone is the higher elevation alpine mountains, which provide scenic amenities which are both different than and generally more spectacular than those found in most of Eastern Montana and the Colstrip area. Portions of both the Bighorn and Beartooth Mountains are contained within this region. The Bighorn Mountains are located to the south of Colstrip and lie mostly in Wyoming. The Beartooth Mountains are situated in the southwest extremity of the one-day travel region near Red Lodge, Montana. Both mountain ranges rise considerably higher in elevation than the other lands in this region. The Beartooths reach an elevation of 12,000 feet while the Bighorns rise to approximately 10,000 feet. By any standard, the alpine landscapes associated with these mountain ranges are highly scenic, containing numerous streams and lakes, as well as dramatic, shear rock facings, pine forests and meadows.

Although less visually dramatic, the Pryor Mountains, located at the northwest extreme of the Bighorn range, possess similar scenic amenities as the Bighorn and Beartooth Mountains. This range reaches elevations of approximately 7,000 feet. The landforms are predominantly steep to rolling, and are dissected by numerous live streams and drainages. Ponderosa pine and grasslands are the predominant vegetation types.

Open, rolling grassland areas containing numerous shallow gullies and ravines are another form of landscape commonly found in the travel region. Ranging in elevation from 2,800 to 3,100 feet, these grassland areas are generally devoid of both trees and water bodies, and are found primarily north and northeast of the Bull Mountains as well as to the south of Billings. The degree of variation in topography and diversity of color and texture associated with this landscape is considered less than that found in the Colstrip area.

Flat, open agricultural valleys create yet another dominant visual landscape within this region. These areas are located primarily in the western portion of the region between Billings and the Bull Mountains and are characterized by their vastness, with varying patterns and textures created by the agricultural activity interspersed with occasional glacial lakes. In general, these areas do not possess the level of visual interest or integrity associated with the landscape found in the Colstrip area.

Portions of the Crow Indian Reservation contain badland areas, which differ significantly from those landscapes previously described. These areas are characterized by rugged topography and colorful, horizontal bands of exposed soils and rock. As such, they represent a somewhat unique scenic feature in the region.

Another isolated and visually significant area is the Bighorn Canyon and Reservoir. Designated a National Recreation Area, it is a popular recreational site due to the proximity to water and superb scenic amenities.

The presence of water generally enhances the visual interest of the landscape, particularly in areas where water features are somewhat scarce. The major rivers within the one-day travel zone include the Yellowstone, Tongue, Musselshell, Bighorn and Little Bighorn. Many of these rivers are characterized by broad, flat valleys which have been developed to varying degrees because of the availability of suitable terrain and water. Therefore, the scenic quality of these river-dominated landscapes tends to vary significantly due to the integrity of the setting.

Quality of Mining Areas A and E Visual Resources According to BLM Ratings of Southeastern Montana and Northern Great Plains Region:

This section focuses specifically on the visual amenities of the Mining Areas A and E that have previously been evaluated for their scenic quality by the Bureau of Land Management (BLM). The BLM is the only governmental agency which has conducted such studies on scenic quality in eastern Montana, therefore, providing some frame of comparative reference.

This discussion will prove helpful in placing the visual resources associated with Areas A and E into regional perspective.

The BLM evaluated the lands according to the degree of scenic diversification provided by the landforms, color, water and vegetation inherent to the landscape. Lands were given additional importance if they contained any regionally unique features; and finally, the effects of many are considered. The evaluation criteria are included in table 1.

Based upon the rating given in each of these categories, the lands are placed in one of three scenic quality and related management practices categories as shown below:

Class A: The outstanding, rare areas where the superlative quality of the landscape dictates a management policy of protection of the scenic values in all land use decisions.

Class B: Above average scenery--although scenic values are high, they are not necessarily the dominant facts in determining management practices.

Class C: Average scenery--protection of scenic qualities does not determine land management practices.

The South Rosebud Planning Unit, evaluated by BLM, includes portions of the east and west fork of Armells Creek, Rosebud Creek and the Tongue River and those areas lying between them. This region has numerous intermittent streams, creeks and drainages, deeply dissected plateaus and valleys. Ponderosa pine covered hills with exposed brightly colored soils and frequent plateaus and valley of grasslands and shrubs and rock outcrops dominate the visual character of the landscape.

None of the lands were classified by the BLM as Class A scenery. Streams and related grassland and valley areas were generally placed in Class C, while ridges and hills having ponderosa pine and exposed soil colors were classified as Class B.

Table 1: BLM SCENIC EVALUATION SHEET

KEY FACTORS	A	B	C
Land Forms	Vertical or near vertical cliffs, spires, highly eroded formations, massive rock outcrops, severe surface variation.	Steep canyon walls, mesas, small scale erosional patterns, variety in size and shape of land forms.	Rolling hills, foothills, flat valley bottoms.
	4	2	1
Color	Rich color combinations variety or vivid contrasts in the color of soil, rocks, vegetation or water.	Some variety in colors and contrast of the soil, rocks and vegetation, but not dominant.	Subtle color variations, little contrast, generally muted tones. Nothing really eye catching.
	4	2	1
Water	Still, chance for reflections or cascading white water, a dominant factor in the landscape.	Moving and in view or still but not dominant.	Absent or present, but seldom seen.
	4	2	1
Vegetation	A harmonious variation in form, texture, pattern and type.	Some variation in pattern and texture but only one major type.	Little or no variation, contrast lacking.
	4	2	1
Uniqueness	One of a kind or very rare within region.	Unusual but similar to others within the physiographic region.	Interesting in its setting, but fairly common within the physiographic region.
	6	2	1
Intrusions	Free from aesthetically undesirable or discordant sights and influences.	Scenic quality is somewhat depreciated by inharmonious intrusions, but not so extensive that the scenic qualities are entirely negated.	Intrusions are so extensive that all scenic qualities are entirely nullified.
	2	1	-4
	TOTAL SCORE: 15 or more = Class A	10-14 = Class B	0-9 = Class C

APPENDIX E-7

ECONOMIC-DEMOGRAPHIC SIMULATION MODEL

APPENDIX E-7

A. The Model[1]

The economic-demographic simulation model provides a framework within which the interaction of the demographic structure and the economic base of the study can be studied. The components of the model and the purposes they serve are as follows:

> Demographic Submodel: This submodel starts with a base population of the study area and predicts the number who are expected to be born and die during the year. Part of the new population then joins the labor force based on a set of assumed age-sex-race specific labor force participation rates. The output of this submodel includes population and labor force.
>
> Economic Submodel: The economic submodel begins with the assumptions about the level of basic activity in the area and generates the local employment and real income levels by industry.
>
> Racial Allocation of Employment Submodel: The available Northern Cheyenne labor force is compared to the total number of jobs assumed to be available to the Cheyenne. The proportion of new jobs in a given industry that will be available to the Cheyenne is referred to as the Northern Cheyenne "entry factor" and was estimated to reflect both the historical level of participation of the way in which this might change in the future. Northern Cheyenne employment is then determined by whichever factor becomes limiting first--available labor force or available jobs. Possible non-Indian employment by industry is then calculated by subtracting the Indian employment from the total.
>
> Migration Submodel: The Anglo total employment is then compared to the available Anglo labor force from the demographic submodel and the implied unemployment rate is calcualated. If this rate is outside the normal range, migration is assumed to occur to bring the rate within the range. The in-migrants (out-migrants) are then added (subtracted) to the base population, and the model proceeds to the next year.

The model generates five basic tables:

(1) Population--Age, Sex, Race

(2) Labor Force--Age, Sex, Race

(3) Employment--Race, Industry

(4) Unemployment Rate--Race

(5) Labor Income--Race

The interrelationships of the four submodels and more detail about the way in which their components interact are shown in Figure 1.

B. Important Demographic Assumptions

The vital rates (both birth and death) of the population and the labor force participation rates of the area residents are important factors in determining the impact of resource development on Rosebud County.

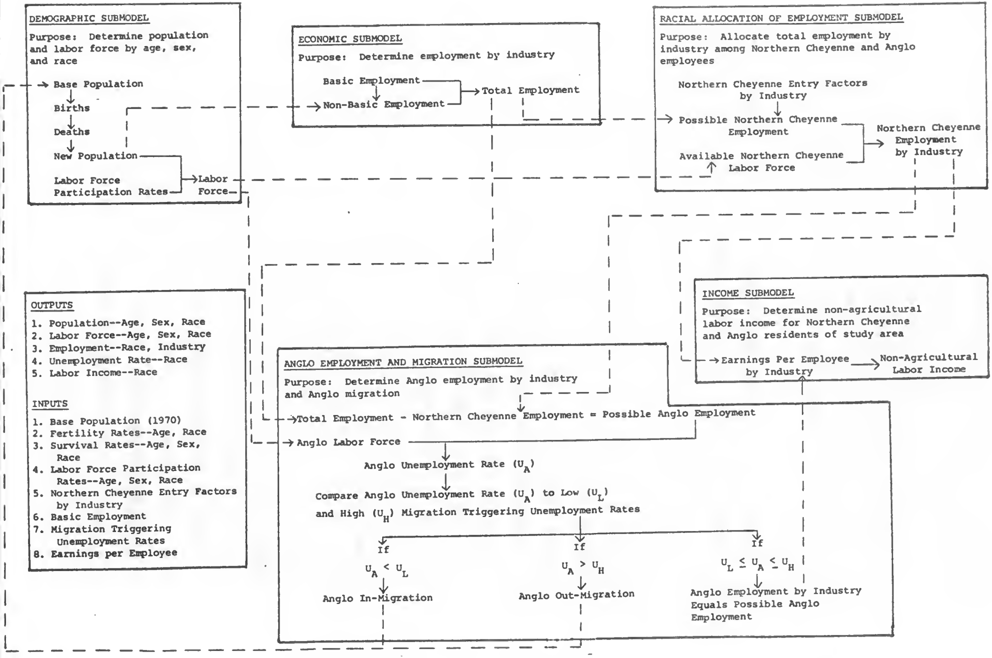
Fertility rates were derived by taking the annual average number of live births over the period 1969-1971 by age and race of mother for the state of Montana and then calculating rates based on the 1970 census population. These rates were then examined futher to check their applicability to the study area. Data provided by the Indian Health Service showed that fertility rates for the service unit containing the Northern Cheyenne Reservation are close to Montana all-Indian rates. These data also indicated that although there was a substantial decrease in the rates between 1960 and 1970 (from 246.8/1000 to 186.1/1000 women of child-bearing age), there is no evidence that there will be a decline of this magnitude over the decade of the 1970's.

This, along with the importance of large families to the Northern Cheyenne, leads to the assumption that future fertility rates will remain at the 1970 level. Although the rates could fall in the future, such a reduction would not significantly affect the size of the Indian labor force until after 1990. The reduction, however, would cause the Northern Cheyenne population to be smaller than projected.

Survival rates were obtained in much the same manner. Average annual deaths by age, sex, and race for the period 1969-1971 were divided by the 1970 census population in each age-sex-race group. These rates were assumed to remain constant at the 1970 level.

FIGURE 1

ROSEBUD COUNTY ECONOMIC-DEMOGRAPHIC SIMULATION MODEL


DEMOGRAPHIC SUBMODEL
Purpose: Determine population and labor force by age, sex, and race
Base Population
Births
Deaths
New Population
Labor Force Participation Rates
Labor Force
ECONOMIC SUBMODEL
Purpose: Determine employment by industry
Basic Employment
Non-Basic Employment
Total Employment
RACIAL ALLOCATION OF EMPLOYMENT SUBMODEL
Purpose: Allocate total employment by industry among Northern Cheyenne and Anglo employees
Northern Cheyenne Entry Factors by Industry
Possible Northern Cheyenne Employment
Available Northern Cheyenne Labor Force
Northern Cheyenne Employment by Industry
OUTPUTS
1. Population--Age, Sex, Race
2. Labor Force--Age, Sex, Race
3. Employment--Race, Industry
4. Unemployment Rate--Race
5. Labor Income--Race
INPUTS
1. Base Population (1970)
2. Fertility Rates--Age, Race
3. Survival Rates--Age, Sex, Race
4. Labor Force Participation Rates--Age, Sex, Race
5. Northern Cheyenne Entry Factors by Industry
6. Basic Employment
7. Migration Triggering Unemployment Rates
8. Earnings per Employee
INCOME SUBMODEL
Purpose: Determine non-agricultural labor income for Northern Cheyenne and Anglo residents of study area
Earnings Per Employee by Industry
Non-Agricultural Labor Income
ANGLO EMPLOYMENT AND MIGRATION SUBMODEL
Purpose: Determine Anglo employment by industry and Anglo migration
Total Employment - Northern Cheyenne Employment = Possible Anglo Employment
Anglo Labor Force
Anglo Unemployment Rate (U_A)
Compare Anglo Unemployment Rate (U_A) to Low (U_L) and High (U_H) Migration Triggering Unemployment Rates
If
$U_A < U_L$
Anglo In-Migration
If
$U_A > U_H$
Anglo Out-Migration
If
$U_L \le U_A \le U_H$
Anglo Employment by Industry Equals Possible Anglo Employment

The most important demographic assumptions are those that relate to how the resident population will participate in the labor force. This concept is referred to as the labor force participation rate (LFPR) and is a measure of the number of employed and unemployed persons seeking work expressed as a percentage of the populatioon of working age. If, for example, there were 80 persons of a given race, sex, and age, and 50 of these were employed and ten were unemployed but seeking work, then the number in the labor force would be 60. The LFPR for this particular cohort would be 60/80 or .75.

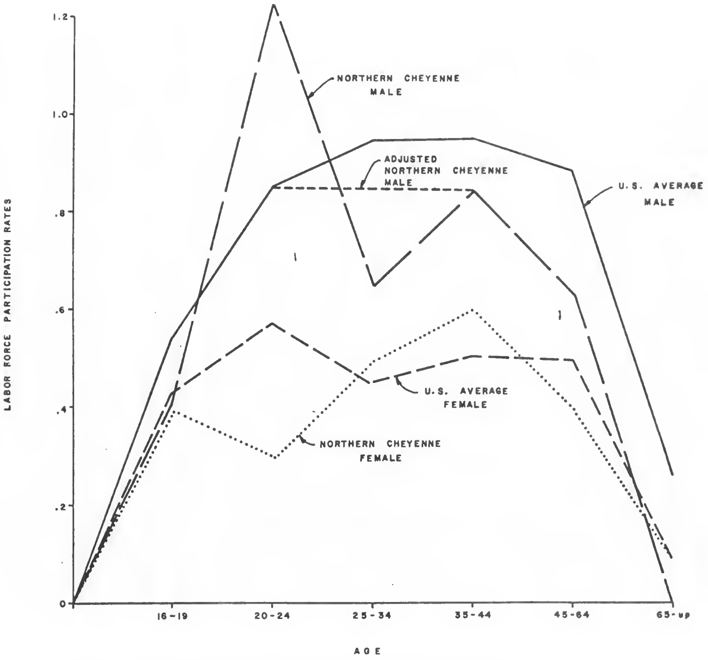
In general, the higher the LFPR, the smaller the population necessary to fill a given number of jobs. This results in a higher level of per capita income, since the ratio of employed persons to total population is higher. In order to do any analysis of the impact of future events, it is necessary to look carefully at the LFPR of both the Anglo and Northern Cheyenne residents in the study area. The Indian and Anglo LFPR along with the U.S. rates are graphed in Figure 2 and Figure 3.

The rate for 20-24 year old male Northern Cheyennes was calculated to be greater than one, which means that there are more males of this age in the labor force than there are total males of this age. Clearly, this is not reasonable. Furthermore, the rate for 25-34 year old Northern Cheyenne males were combined with the resulting LFPR indicated by the light, dotted line in Figure 2. The same results were observed for the Anglo males with both the 20-24 and 35-44 rate greater than one and the 25-34 rates too low. These three age groups were combined with the LFPR indicated in a like manner in Figure 3.

The pattern of participation for Northern Cheyenne males and females is somewhat below the average participation for the United States as a whole. Likewise, labor force participation for Anglo women in the study

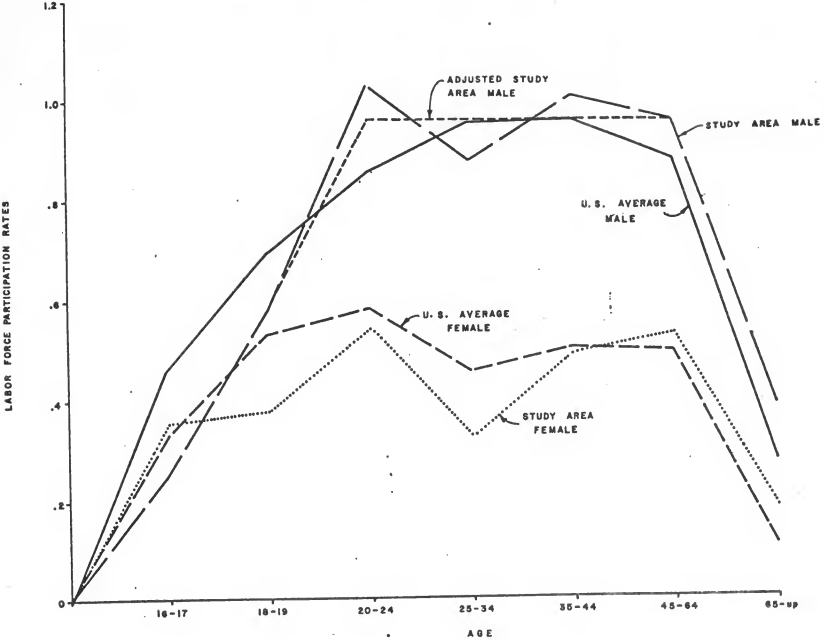
FIGURE 2

LABOR FORCE PARTICIPATION RATES
NORTHERN CHEYENNE
1970



Sources: Derived from U.S. Bureau of the Census, Summary Tape Data.
"U.S. Labor Force: Projections to 1990", Monthly Labor Review (July, 1973).

FIGURE 3
LABOR FORCE PARTICIPATION RATES
ANGLO
1970



Sources: Derived from U.S. Bureau of the Census, Summary Tape Data.
"U.S. Labor Force; Projections to 1990", Monthly Labor Review (July 1973).

area is below that for U.S. women. It is well known that persons drop out of the labor force (i.e., no longer "actively" seek work) if, over an extended time, they fail to find employment. However, these discouraged labor force participants may rejoin the labor force if employment opportunities become available in the area. As coal development activity increases in the study area, it would be unrealistic to assume that the LFPR will remain at the 1970 level.

For this reason, the futures analysis has assumed that the participation rates will converge to projected U.S. rates by the year 1990. This represents an upper limit to the level of participation in the study area and has the desirable property that the bulk of the adjustment will come from increased participation of young people facing the labor force entry decision for the first time. It is highly likely that these young people, if opportunities exist, will participate in a way increasingly similar to their age-sex counterparts elsewhere in the United States.

C. Important Economic Assumptions

A critical question of the analysis of future developments in the study area concerns the racial distribution of the jobs that are created. Clearly, it is not sufficient to simply talk about the total number of jobs to be created; the distribution of the jobs between Northern Cheyenne and Anglo workers also must be addressed. The employment of Northern Cheyennes by industry was approached in the following manner:

> The available Northern Cheyenne labor force was calculated. This was assumed to be .95 of the total labor force, i.e., "normal" unemployment was assumed to prevent the unemployment rate from falling below five percent. However, the rate can still go above this level.
>
> An assumption was made about the proportion of new jobs in any given industry that would be available to the Northern Cheyennes. These "entry factors" reflect both the historical level of participation of the Cheyennes in a given industry plus an estimate of the way in which conditions might change in the future. For example, even though there were no Cheyennes working in the mining sector in 1970, it was assumed that they

> would have access to fifteen percent of the new mining jobs that become available. This means that if enough Northern Cheyenne workers are available, they will get ten percent of the jobs.

Although the 15 percent entry factor seems low for the mining and construction sectors, the attitude of some people on the reservation is that the energy companies have not and will not employ a substantial number of Northern Cheyennes because of problems associated with lack of skill, absenteeism, and discrimination. The validity of the 15 percent figure will depend on the hiring practices of the development companies; but it should allow the estimation of at least the order-of-magnitude of the impacts on the Northern Cheyenne. The entry factors along with the 1970 distribution are shown in Table 1.

Application of the entry factors to the number of new jobs in an industry then generates an estimate of the number of jobs available to Northern Cheyenne workers. If the available Northern Cheyenne labor force exceeds the available jobs, then actual Northern Cheyenne employment is assumed equal to available employment by industry, and the difference between the Northern Cheyenne labor force and employment is the number of unemployed.

If the number of available jobs exceeds the available Northern Cheyenne labor force, Northern Cheyenne employment is limited to the available force, the unemployment rate is five percent, and the available Northern Cheyennes are allocated by industry proportionally. In either case, Anglo employment by industry is calculated as the difference between total employment and Northern Cheyenne employment.

The other set of assumptions for the economic model concerned the responsiveness of the service and trade sectors (induced activity) to new income in the area. This new income will be generated by changes in agriculture, mining, or manufacturing activity.

TABLE 1

ENTRY FACTORS FOR ROSEBUD COUNTY

Sector	Entry Factor	Percentage of jobs held by Northern Cheyennes (1970 Census)
Agriculture	.18	18.0
Mining	.15	----
Construction	.15	.1
Manufacturing	.70	73.6
Transportation, Communication, Public Utilities	.15	11.4
Trade	.15	7.7
Finance, Insurance, Real Estate	.11	11.0
Services	.25	19.2
Government	.50	41.3
Other	.05	----

Source: Derived.

The short time series of employment and income data (five years) makes it questionable whether analytic estimation of this relationship can be done. Furthermore, it is not clear that such sophisticated analysis would be more reliable than a simpler method given the amount of structural change occurring in the county.

It is quite reasonable to assume that induced activity is directly related to the level of income in the study area. Thus, the level of induced employment can be expressed as a fraction of labor income and is the ratio of a particular sector's employment to income. If trade employment, for example, was 100 and income was 10.0 million dollars, the ratio would be .00001; or, for every dollar of income, there are .00001 employees in the trade sector, Thus, one additional person will be employed in the trade sector for every $100,000 of additional income.

Induced employment is assumed to occur in the following seven sectors:

(1) construction

(2) transportation, communication, and public utilities

(3) trade

(4) finance, insurance, and real estate

(5) services

(6) government

(7) other (self-employed)

Clearly, not all of the employment in each of these sectors can be attributed to residential activity within the county. One of the more obvious sectors for which this is the case is the transportation sector. Employment in the railroad industry is not related to the level of income in the study area, and if this "basic" activity is not removed from the employment total before the ratio is calculated, the ratio will be too high and this will cause the industry to grow too fast. Therefore, the following adjustments were made.

Railway employment was removed from the transportation sector.

Non-profit and welfare organizations were removed from services.

State and federal employment was removed from the government total.

The ratio for the "other" sector was calculated as a weighted average of the ratios for the trade, finance, and service sectors.

The ratios, both before and after the adjustments, are given in Table 2. As indicated, the adjustments had a substantial effect on the size of the ratios.

TABLE 2

RATIOS OF INDUCED EMPLOYMENT TO LABOR INCOME
(EMPLOYEES PER $1,000 PERSONAL INCOME)

Sector	Unadjusted	Adjusted
Construction	.0014	.0014
Transportation, Communication, Public Utilities	.0088	.0035
Trade	.0104	.0104
Finance, Insurance, Real Estate	.0009	.0009
Services	.0189	.0109
Government	.0212	.0125
Other	.0148	.0083

Source: Derived.